

EU and Europe: Regional Strengths and Weaknesses

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Deliverable Abstract

This policy brief analyses the strengths and structural vulnerabilities of the European semiconductor industry, highlighting technological leadership in key areas such as advanced equipment manufacturing and R&D, alongside persistent challenges notably fragmentation of regional ecosystems, shortage of specialist skills and dependence on external suppliers in critical supply chain segments.

The aim is to identify areas for strategic intervention, including strengthening training and attracting talent, greater integration between national and regional initiatives, and Identify strategic choke points in the supply chain where Europe can consolidate its competitiveness. In line with the spirit of the Chips Act, it emphasises the importance of promoting more coordinated governance, more robust industrial cooperation and a shared strategic vision to build a more resilient and innovative European semiconductor ecosystem.

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Executive summary

The European semiconductor industry stands out for important strengths, including global leadership in the production of advanced equipment, scientific excellence and prominent specialisations in key sectors such as automotive and industrial automation. Thanks to the efforts of the European Commission and initiatives such as the Chips Act, Europe is progressively strengthening its position in a highly competitive and strategic sector.

At the same time, some challenges emerge: among these, the fragmentation between regional ecosystems, the lack of specialised skills and a strong dependence on foreign suppliers in crucial areas of the supply chain. These elements, if addressed in a coordinated manner, can offer new opportunities to build a more resilient and innovative ecosystem.

In light of this framework, this policy brief aims to provide insights and perspectives on how to enhance existing resources, strengthen synergies between research, industry and training, and foster greater strategic cohesion between different European actors. These are elements which, if considered in the ongoing debate, could contribute to further strengthening the effectiveness of European policies in the semiconductor sector, in an ever-changing global context. In light of this framework, this policy brief provides insights and perspectives focused on three key strategic actions: Investing in specialised human capital through central coordination for training, strengthening European governance with the harmonisation of standards for SMEs, and strategically reconfiguring value chains, identifying critical choke points and enhancing chip diplomacy and shared infrastructure.

1. Introduction

This policy brief aims to examine the structural strengths and weaknesses of the semiconductor industry within the European Union. It primarily seeks to identify areas where Europe has strategic assets, such as the production of highly specialised equipment, excellence in scientific research, and niche specialisations. It also looks at the critical issues that continue to limit global competitiveness: specifically, a heavy dependence on foreign supply chains and poor industrial coordination.

The objective is to provide an overview of the current European semiconductor landscape, assess its positioning within the global value chain, and offer policy recommendations to EU policymakers working to strengthen the Union's strategic resilience. The analysis incorporates desk research, and is also based on a series of interviews conducted with experts and stakeholders from the semiconductor ecosystem, whose insights helped define the findings and recommendations in this brief. This brief is particularly timely: it intervenes at a stage where open strategic autonomy is driving EU industrial and digital policies, while the EU Chips Act (2023–24) is still in its phase of implementing and defining monitoring mechanisms. The recommendations provided concern near-term policy choices and are intended as practical and operational guidance.

The European semiconductor sector is shaped by a diverse set of regional capabilities, industrial specialisations, and technological assets. Across the Union, certain Member States have established solid positions in specific market segments: power electronics, research and innovation, lithography, and equipment manufacturing. For instance, countries like Germany, France, Italy, the Netherlands, Austria, Belgium, and Ireland have become central hubs for semiconductor development and production, often specialising in components for key industries such as automotive, industrial automation, healthcare, and telecommunications¹. Others are in earlier stages of development or focus on complementary niches. This diversity is a strength, but it also presents coordination challenges when aiming to build a more integrated and competitive European semiconductor ecosystem.

1.1 A FOREWORD: GLOBAL INTERDEPENDENCE AS A STRUCTURAL REALITY

By passing the Chips Act², the European Union has taken a significant move towards promoting the development of home-based strengths and hard strategic dependencies, especially after the 2013 strategy failed to increase the EU's share of microchip production³. As implementation progresses, a clear understanding of existing regional strengths and structural gaps becomes essential. But any discussion of strengths and gaps must be framed within a global reality: there are no absolute strengths or weaknesses in semiconductors, only interdependent ones.

1 Ragonnaud, G. (2022, November). The EU Chips Act: Securing Europe's supply of semiconductors (PE 733.596). European Parliamentary Research Service. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733596/EPRS_BRI\(2022\)733596_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733596/EPRS_BRI(2022)733596_EN.pdf)

2 Regulation (EU) 2023/1781 <http://data.europa.eu/eli/reg/2023/1781/oj>

3 European Court of Auditors. (2025). Special report 12/2025: The EU's strategy for microchips – Reasonable progress in its implementation but the Chips Act is very unlikely to be sufficient to reach the overly ambitious Digital Decade target <https://www.eca.europa.eu/>

The sector's increasing complexity has made it virtually impossible for any single company, or even country, to be self-sufficient. Today, no firm can alone master the full spectrum of expertise required: ultrapure chemicals, high-end software, optical systems, thin-film deposition, or advanced inspection. Being a highly specialised and innovative sector, the production process is divided into several stages distributed across various regions of the world and is heavily dependent on a complex and interconnected global network of suppliers. Even the most advanced players rely on each other's strengths: the Dutch champion in semiconductors, ASML, for instance, is the world's only supplier of EUV lithography systems, arguably the most sophisticated tools ever built. Yet even ASML depends on dozens of suppliers across continents⁴. Moreover, EUV lithography machines are not the only tools required to manufacture cutting-edge chips. For the inspection of finished semiconductors and for the detection of defects at the nanoscale, additional highly advanced systems are needed, to ensure product performance and yield⁵. This specific case demonstrates that even the most advanced players rely on each other's capabilities. ASML is Europe's flagship example: a world-leading niche champion, yet structurally dependent on global suppliers and exposed to extra-EU export-control pressures. At the same time, Europe excels in scientific research but faces challenges in transforming innovations into industrial products. Furthermore, the transformation of the sector driven by electrification and digitalisation in sectors such as automotive, requires Europe to rapidly modernise its capabilities to remain competitive in the context of global changes.

In the United States **NVIDIA** is the leading designer of GPUs, thanks to a key strategic insight: the same chips once used for gaming and graphics⁶ could be repurposed to accelerate AI training. Today it is one of the most valuable technology companies in the world. However, NVIDIA has never fabricated a single chip itself, it fully relies on a complex, global supply chain to turn its designs into physical products. Taiwanese **TSMC** has the main production phases in its hands, which are carried out in its foundries while using tools and materials from all over the world. It is therefore clear that without access to this international production base, **NVIDIA's** design leadership could not translate into the dominant position it holds on the market today.

Similarly, China today is the world's largest consumer and assembler of chips. It plays a solid role especially in the production, assembly and packaging segments, and boasts a strong base of public and private investments, with the aim of expanding its national capabilities in the sector⁷. Despite this growing footprint, it remains heavily dependent on high-end chip imports. The Chinese cutting-edge AI chip relies on chemicals from Japan, production equipment from the Netherlands, and design software from the U.S.⁸ In 2024, the country spent more on importing semiconductors than on oil⁹, with a large portion of these imports coming from neighbouring Asian economies. In this context, any effort to strengthen the European semiconductor industry naturally takes place within a global framework. The strengths and weaknesses of the European semiconductor industry are inextricably linked and must be considered together. For the EU, the objective is to craft a strategy that leverages Europe's powerful assets and collaborates with trustworthy international partners to manage global dependencies and secure critical supplies.

4 ASML Annual Report, 2024 <https://ourbrand.asml.com/m/79d325b168e0fd7e/original/2024-Annual-Report-based-on-US-GAAP.pdf#page=1>

5 Chip War 2.0: The Global Battle for Semiconductor Supremacy: Chris Miller, at World Knowledge Forum 2024.

6 Wang, J., Hsu, J., & Qin, Z. (2024). A Comprehensive Analysis of Nvidia's Technological Innovations, Market Strategies, and Future Prospects. International Journal of Information Technologies and Systems Approach (IJITSA), 17(1), 1-16. <https://doi.org/10.4018/IJITSA.344423>

7 Lee, J., & Kleinhans, J.-P. (2021). Mapping China's semiconductor ecosystem in global context: Strategic dimensions and conclusions. Stiftung Neue Verantwortung. <https://www.stiftung-nv.de/en/publication/mapping-chinas-semiconductor-ecosystem-global-context>

8 Oxford Debate: 'China Simply Cannot Reach Semiconductor Supremacy by 2030. <https://asiasociety.org/switzerland/oxford-debate-china-simply-cannot-reach-semiconductor-supremacy-2030#:~:text=Even%20though%20China%20is%20likely,%2C%20countered%20Jan%2DPeter%20Kleinhans>

9 Rostum E., (2025) Chip Export Control don't work, CEPA

2. Europe strategic assets

This section is aimed at analysing Europe's competitive resources, taking into account the cyclical and interdependent character of the semiconductor sector, underlining that every strength must be able to evolve in order to remain relevant. The aim is to show how areas of leadership can also constitute vulnerabilities, depending on Europe's ability to adapt to a constantly changing technological balance. The complexity of the value chain means that a leadership position in one node may coexist with vulnerabilities elsewhere. With this awareness it is clear that Europe's challenge must not only concentrate on defending what it has, but also be able to critically evaluate whether the present advantages can still translate into long-term resilience and global influence.

2.1 TECHNOLOGICAL LEADERSHIP AND EXTERNAL DEPENDENCIES

The EU holds a strong position as a net exporter in the semiconductor equipment segment, thanks to the global leadership of several European manufacturers in highly specialised machinery for wafer and chip production.¹⁰ Among these, Europe currently prominently holds a position of supremacy in one of the most critical technological hubs of the semiconductor value chain: advanced lithography. ASML's importance to Europe also lies in its role as a catalyst for a European innovation ecosystem. ASML has built a robust innovation ecosystem over time, investing more than €4.3 billion in R&D in 2024 and collaborating closely with leading research centres such as **imec**, **Fraunhofer**, **CEA-Leti**, and strategic European universities (**Delft**, **Eindhoven**, **Twente**). The opening of the High-NA EUV Lab with imec in the Netherlands represents a further step towards the industrialisation of the next generations of lithography.¹¹ Europe's critical industrial contribution is exemplified by ASML's near-exclusive dependence on **Carl Zeiss SMT**, a German company that supplies essential optical components, such as lenses and mirrors, used in EUV systems.¹² This collaboration strengthens the strategic ties between the Netherlands and Germany, helping to distribute value and technological expertise within the Union. At the same time, however, it highlights the risks associated with dependence on a single supplier for a critical element of the value chain: any production problems or disruptions at Carl Zeiss SMT could seriously compromise ASML's ability to deliver its systems, even temporarily halting operations.

However, ASML's global reach exposes it to geopolitical risks and heavy dependencies on countries outside the EU. Its EUV machines, which integrate over 100,000 components supplied by approximately 5,000 global companies, are only 15% manufactured in-house, with the remainder coming from strategic partners such as **Veeco** and **Applied Materials** (USA), **Tokyo Electron** and **Lasertec** (Japan), **IMS Nanofabrication** (Austria), **SUSS MicroTec** (Germany) and many others¹³. This heavy exposure to external suppliers increases the risk that trade restrictions or diplomatic crises could compromise production continuity¹⁴. This shows how even a European champion remains exposed to strategic decisions outside

10 Bonnet, P., Ciani, A., Molnar, J., & Nardo, M. (2022). EU's strengths and weaknesses in the global semiconductor sector. European Commission, Joint Research Centre. <https://doi.org/10.2760/XXXXXX>

11 TU/e will enhance the joint research program and train PhD students in plasma physics, mechatronics, optics and AI. ASML is investing €80 million over the next decade at TU/e, primarily for PhD programs and infrastructure. ASML Annual Report, 2024 <https://ourbrand.asml.com/m/79d325b168e0fd7e/original/2024-Annual-Report-based-on-US-GAAP.pdf#page=1>

12 ASML Annual Report, 2024

13 John VerWey, (2024) Tracing the Emergence of Extreme Ultraviolet Lithography, Center for Security and Emerging Technology, <https://doi.org/10.51593/20240003>

14 ASML Annual Report, 2024

the EU. This is confirmed by the episode in 2019, when strong diplomatic pressure from the US prompted the Dutch government not to grant ASML a licence to export its EUV machines to China's **SMIC**, despite the absence of formal legal requirements to do so¹⁵. As confirmed in its 2022 report, ASML itself has repeatedly expressed concern about a potential scenario of "decoupled technology ecosystems", in which the world is divided into autonomous blocs, one Chinese, one American, one European, with separate rules, suppliers, and markets¹⁶. This prospect, in addition to undermining innovation, represents a real risk for a company that bases its strength on a global supply chain and a highly internationalised workforce. Even if in the short term a total decoupling appears difficult to achieve, it is still interesting and necessary to see what its implications and concrete consequences would be. Any global technological fragmentation could in fact lead to the birth of a bifurcated market, in which countries would progressively side with the United States or China, based on political and technological logic. Long-term consequences for global innovation would include duplication of efforts, with countries developing similar technologies in parallel, wasting resources and slowing progress, and a drastic reduction in knowledge exchange, due to restrictions on cross-border collaboration. Furthermore, the creation of parallel supply chains and infrastructure would lead to a significant increase in costs, both for businesses and consumers¹⁷. Given the crucial importance of China to the Dutch company, which accounted for 36.1% of total net sales for the company in 2024¹⁸. Such developments, including the push towards technological sovereignty and export controls, could lead to negative effects for the company and on its growth prospects. One example is that countries subject to export control restrictions could in turn introduce countermeasures to counteract the effects of actions taken by other States¹⁹. Furthermore, as highlighted by some interviewees, another critical point concerns the fragmentation of governance between European and national competences. For example, trade is an EU competence, while export control remains national, making a coordinated response to geopolitical and trade challenges difficult. The ASML example illustrates that true support for champions lies in strategically leveraging the European innovation ecosystem while actively managing internal and external dependencies to sustain global connectivity and long-term resilience.

2.2 RESEARCH EXCELLENCE AND INDUSTRIAL GAP

As a strategic technology, semiconductors involve some of the highest global expenditures in research and development²⁰, second only to the pharmaceutical and biotech industries. Especially in the semiconductor industry, which exists in a constant state of flux, innovation is required across the entire value chain. European companies consistently invest over 15% of their revenues in next-generation technology research, placing them among the global leaders in innovation intensity²¹. European Research and Technology Organizations (RTOs) are pioneers in the techniques behind the production of some of the most advanced semiconductors in the world. However, there is also recognition of a gap between academia and industry, which slows down the transition from innovation to commercialisation. The "triple helix" of university-industry-government is often cited as the recipe for a knowledge-based society and

15 Aresu, A. (2022). Il dominio del XXI secolo: Cina, Stati Uniti e la guerra invisibile sulla tecnologia. Feltrinelli.

16 ASML Annual Report, 2022

17 Feng, J. (2022). The Costs of U.S.-China Semiconductor Decoupling. Council on Foreign Relations. <https://www.cfr.org/blog/costs-us-china-semiconductor-decoupling>

18 ASML Annual Report, 2024

19 ASML Annual Report, 2024, International conflicts and nationalization of ASML's assets can negatively affect business, especially considering that Taiwan's customers accounted for 15.4% of total net sales in 2024 (29.3% in 2023), while South Korea's customers accounted for 22.7% in 2024 (25.2% in 2023). Political tensions in these regions, such as relations between Taiwan and China or hostilities between South Korea and North Korea, could undermine ASML's ability to serve these strategic markets.

20 European Semiconductor Industry Association, https://www.eusemiconductors.eu/sites/default/files/ESIA_Key%20Recommendations%202024-2029_digital_final_0.pdf

21 Eur-Lex 52022DC0045, Communication from the commission to the EU Parliament, the council, the EU economic and social committee and the committee of the regions, A Chips Act for Europe.

innovation ecosystem²². An in-depth study conducted by Interface (formerly Stiftung Neue Verantwortung), a European think tank specialising in technology and public policy, analysed trends in scientific research on semiconductors since 1995, examining papers invited to major international conferences in the field, such as the International Electron Devices Meeting (IEDM), the International Solid-State Circuits Conference (ISSCC) and the Symposium on VLSI Technology and Circuits²³. The main authors of scientific publications in the semiconductor sector are the United States, Japan and the European Union, highlighting the paramount importance that Europe can bring to the R&D sector²⁴. However, transnational collaborations are rare, despite the global nature of the supply chain. In Europe, Belgium, France, Germany, the Netherlands and Italy lead the way in terms of publications. Since 2012, collaboration between universities and industry has increased, but collaboration between countries has stagnated since 2010, with European companies publishing less and limiting partnerships with academia. In the US, on the other hand, publications have grown by 50% since 1995 thanks to federal funding such as that from DARPA, which promotes research geared towards commercial innovation. Countries such as China, the USA, and Singapore invest much more in the crucial phase of applied research, offering direct incentives to enterprises to develop R&D locally and foster commercialisation. For example, the initial success of the US semiconductor industry was fostered by the Stanford Department of Electrical Engineering, which began courses dedicated to the design and manufacturing of integrated circuits as early as 1961. Engineers from the main companies in the sector also contributed to teaching, while collaborations between universities and industry have continued to support the leading role of the USA in the sector to this day²⁵. European instruments such as Horizon are perceived by some as less effective, partly due to administrative complexity and participation requirements, such as the need for transnational collaboration. Administrative difficulties and funding cuts have held back scientific collaboration between Europe and the United States, a crucial element for the semiconductor sector. Furthermore, there is a lack of adequate support for the so-called technological “death valley” (TRL 7–9)²⁶, the riskiest and most expensive phase that brings a prototype to the market²⁷. This gap pushes many advanced innovation activities out of the European Union, compromising the competitiveness of the continent.

To bridge the gap between academic excellence and industrial innovation, Europe must be able to transform its scientific leadership into a concrete strategic lever, exploiting distinctive strengths. This could happen, for example, with AI chips, currently dominated by the USA and China²⁸. Europe's academic excellence, as evidenced by publications in photonic chips, memristors, and neuromorphic computing, combined with consistent industrial and regulatory support, could potentially strengthen its position in AI hardware development²⁹. Indeed, Europe needs to turn its strong research base into industrial capacity by

22 Konstari, P., & Valkokari, K. (2025). Green innovation ecosystems in the semiconductor industry: The role of European research and technology organisations. *Sustainable Futures*, 10, 101127. <https://doi.org/10.1016/j.sftr.2025.101127>

23 Kleinhans, J.-P., Hess, J. C., & Hemmen, L. (2023, June 8). Who is developing the chips of the future? RELOADED. Interface. <https://interface.co>

24 The authors point out that there are limitations in this type of analysis: mainly because there are many other conferences in the field of semiconductor technologies and part of the research is not published in the form of articles presented at conferences.

25 Deloitte (2022), the global semiconductor talent shortage how to solve semiconductor workforce challenges.

26 “The TRL scale comprises nine technology readiness levels (TRL 1 to TRL 9). These levels indicate how far a technology is from being fully applied in its intended environment” Ghent University, (2022) Horizon Europe Insights - Technology Readiness Level: An important measure of research maturity in Horizon Europe, Onderzoektips. <https://onderzoektips.ugent.be/en/bozi/LUYWL8mBwpkzbkhPXLDb4o/#~:text=Technology%20Readiness%20Level:%20what%20is,fully%20established%20in%20Horizon%20Europe>

27 Segler, S. (n.d.). The EIC Transition: Navigating the Valley of Death in European Deep-Tech Innovation. Segler Consulting. Retrieved September 30, 2025, from <https://www.seglerconsulting.com/the-eic-transition-navigating-the-valley-of-death-in-european-deep-tech-innovation>

28 Quantum Community Network & CNRS. (2025). Artificial Intelligence and Quantum Computing White Paper 2025. <https://example.com>

29 European Parliament, What if Europe championed new AI hardware? [https://www.europarl.europa.eu/RegData/etudes/ATAG/2024/762881/EPRS_ATA\(2024\)762881_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/ATAG/2024/762881/EPRS_ATA(2024)762881_EN.pdf)

supporting applied R&D, simplifying funding tools, and strengthening university and industry collaboration. Closing the “death valley” gap is essential to keep advanced innovation and early manufacturing stages within the Union.

2.3 AUTOMOTIVE SECTOR: HISTORIC STRENGTH AND TRANSITION CHALLENGES

One of the few niches where Europe retains a solid and long-standing advantage is in power semiconductors, a segment that plays a central role in one of the Union's most strategic industrial sectors: the automotive industry. Discussing the dynamics between the semiconductor industry and the automotive sector is crucial for several reasons: first and foremost, it is a key sector for European prosperity, as the EU is one of the world's largest vehicle manufacturers. Moreover, the automotive industry is the largest private investor in research and development (R&D) within the region³⁰, and generated over 13 million jobs in 2023, accounting for 6% of total employment in the EU^{31,32}. But above all, the EU automotive sector is undergoing radical transformation, driven by the transition to electric and digital technologies. Semiconductors will become increasingly central to the future of the industry, making investment in European production and diversification of supply chains a strategic priority. Future growth will be driven by the expansion of electric vehicles and the increasing complexity of vehicles, particularly in two key segments: safety (Compound Annual Growth Rate 9.5%), thanks to the mandatory use of Advanced Driver Assistance Systems (ADAS), radar and sensors, and power electronics (Compound Annual Growth Rate 11%), which is essential for energy management in electric vehicles³³.

Modern vehicles, especially electric and connected ones, require increasingly sophisticated chips with greater processing power and energy efficiency³⁴. The traditional approach of the automotive industry, focused on hardware and robust mechanics, is no longer sufficient. Today, close integration between hardware and software is needed, developed in parallel and in an agile manner. Tools such as the digital twin, which virtually replicates the vehicle in the cloud, help to simulate and correct problems early on in the development stages. In this new scenario, closer collaboration between car manufacturers and chipmakers is increasingly becoming necessary, moving beyond the supplier-customer model in favour of integrated co-design³⁵. Faced with this transformation, it is clear that Europe's traditional advantage in power semiconductors and mature nodes, historically central to the automotive industry, is no longer enough. The paradigm is changing, and with it the geography of innovation.

Europe has always been strong in niches such as wide-bandgap semiconductors, such as silicon carbide (SiC) and gallium nitride (GaN), and in sensors, which are essential components for modern electric vehicles. However, these sectors are now facing fierce competition from China, which is backed by massive state subsidies and public investment. For example, Nexperia, a global semiconductor manufacturer headquartered in the Netherlands but subsidiary of the Chinese company Wingtech Technology Co., Ltd has announced plans to invest approximately €184 million to expand its production of wide-bandgap

30 European Commission, Internal market, Industry, Entrepreneurship and SMEs.

31 Bonnet, P., Ciani, A., Molnar, J., & Nardo, M. (2022). EU's strengths and weaknesses in the global semiconductor sector. European Commission, Joint Research Centre. <https://doi.org/10.2760/XXXXXX>

32 In 2023, the automotive sector accounted for 37% of European demand for semiconductors, confirming its position as the main driver, followed by the industrial sector (26%). In contrast, demand is weaker in the ICT and consumer sectors, reflecting Europe's lower level of specialisation in these areas.

33 Bonnet, P., Ciani, A., Molnar, J., & Nardo, M. (2022). *EU's strengths and weaknesses in the global semiconductor sector*. European Commission, Joint Research Centre.

34 Bonnet, P., Ciani, A., Molnar, J., & Nardo, M. (2022). *EU's strengths and weaknesses in the global semiconductor sector*. European Commission, Joint Research Centre.

35 Latré, S., & Placklé, B. (2023). *Enhanced collaboration between car manufacturers and the semiconductor industry promises significant advancements in road safety*. IMEC.

semiconductors in Germany, targeting the automotive and power electronics markets³⁶. Also European companies are responding: STMicroelectronics has announced a multi-billion euros investment to build a silicon carbide production campus in Italy, with the aim of producing 15,000 wafers per week, supported by EU initiatives such as the Chips Act³⁷. Tesla has demonstrated the importance of these innovative materials for electric vehicles, having pioneered the integration of silicon carbide-based inverters in its Model 3 as early as 2018, adopting MOSFETs supplied by STMicroelectronics that enabled significant weight reduction and improved energy efficiency compared to traditional technologies³⁸.

36 Nexperia to Invest 200 Million USD in Hamburg (2024), <https://www.nexperia.com/about/news-events/press-releases/Nexperia-to-Invest-200-Million-USD-in-Hamburg>

37 CNBC (2024), Tech EU approves Italian aid for \$5.4 billion STMicro chip plant

38 IDTechex (2021), Tesla's Innovative Power Electronics: The Silicon Carbide Inverter <https://www.idtechex.com/en/research-article/teslas-innovative-power-electronics-the-silicon-carbide-inverter/23080>

3. Structural Weaknesses and Strategic Gaps

Despite its strengths, Europe faces significant challenges that risk undermining its competitiveness in the semiconductor sector. Structural fragmentation, skill shortages, and heavy dependence on foreign suppliers for critical components all weaken the continent's position. Unlike more centralised players like the US and China, Europe's semiconductor ecosystem is marked by regional clusters with specialised capabilities, which while valuable, also highlight the lack of coordination and unified strategy. This fragmentation limits Europe's ability to act as a cohesive force on the global stage. Addressing these interconnected weaknesses is essential for Europe to build a resilient, integrated semiconductor industry capable of meeting future technological and geopolitical demands.

3.1 LACK OF COORDINATION AND EUROPEAN CLUSTERS

Semiconductor clusters in Europe have long been established, typically forming around key drivers such as large vertically integrated manufacturers or publicly funded research centers³⁹. However, it was the pandemic that highlighted the fragility of the European supply chain, prompting the European Union to recognise the strategic value of semiconductors and the importance of strengthening regional specialisations. Today, Europe's main semiconductor clusters reflect this fragmentation. France's **Minalogic** (Grenoble) is a leader in microelectronics, photonics, and AI applications, supported by strong academic and research institutions. Germany's **Silicon Saxony** (Dresden) stands out for large-scale manufacturing, housing major fabs and R&D institutions. The **High Tech NL cluster** (Eindhoven, Netherlands) is driven by industrial heavyweights like ASML and NXP and focuses on innovation, robotics, and life sciences. Belgium's **DSP Valley** (Leuven) connects cutting-edge microelectronics research, especially through **IMEC**, to applications in smart systems⁴⁰. This regional specialisation is a natural result of Europe's diverse innovation ecosystems, and strong semiconductor clusters bring clear benefits in expertise and focus. However, due to the complexity and interdependence of the semiconductor value chain, no single cluster or Member State can independently cover all stages of production, innovation, and commercialisation. This becomes a strategic issue if the EU aims to act as a unified and competitive player globally. To reduce external dependency, fragmentation must be addressed as a vulnerability, not just a structural feature. This tension becomes especially clear when looking at Pillar II of the EU Chips Act. Unlike Pillar I, which enjoys a degree of EU-level coordination, Pillar II relies almost entirely on national budgets, leaving strategic investments fragmented by design. In the absence of a shared EU framework or guiding document, each Member State moves independently, funding projects based on its own interests. The result is a patchwork of national strategies, with overlapping investments even in similar technology areas. As pointed out by one interviewee, both Onsemi in the Czech Republic and Wolfspeed in Saarland, Germany (non-EU companies working on silicon carbide technologies), have submitted parallel applications for Chips Act-related funding, despite the presence of strong European players in the same field, such as STMicroelectronics, Infineon, and Bosch. This kind of duplication highlights the lack of strategic coherence and underscores how difficult it is for smaller Member States, with more limited resources, to compete on

39 Huggins R. (2022), The Future of Europe's Semiconductor Industry: Innovation, Clusters and Deep Tech, Cardiff University

40 Huggins, R., Johnston, A., Munday, M., & Xu, C. (2023). Competition, open innovation, and growth challenges in the semiconductor industry: The case of Europe's clusters. *Science and Public Policy*, 50(3), 531–544. <https://doi.org/10.1093/scipol/scad005>

equal footing for large-scale investments. Given the central role research plays in Europe's semiconductor strategy, this also highlights a structural imbalance: while scientific excellence is well-supported, much less attention is given to development and commercialisation. As a result, industrial clusters receive limited direct support⁴¹. This research-oriented approach is further reflected in the composition and behaviour of the European semiconductor industry, which remains highly regionalised and dominated by SMEs. These smaller firms often focus on specific segments of the value chain within their local clusters and, while innovative, typically lack the scale and investment capacity needed to grow internationally. In fact, the structure of the sector has contributed to three recurring challenges: a shortage of investment, weak entrepreneurial dynamics, and difficulty in scaling up. Moreover, the absence of strong internal demand for leading-edge semiconductor technologies, particularly from downstream consumer industries, has led many promising European innovators to relocate abroad, especially to the United States, where conditions for commercialisation are more favourable⁴². A further barrier faced by SMEs in Europe is their limited access to strategic projects and alliances. This creates a significant hurdle, as smaller firms struggle to engage in collaborative efforts critical for scaling and innovation. As stressed by experts, national initiatives tend to operate in silos, with little communication or integration across countries. For instance, substantial projects like Germany's Semiconductor X, funded with multi-million euro budgets, aim to build digital ecosystems, but without a coordinated European approach, their impact remains limited.

In order to ensure that regions are truly involved in European strategies, it is essential to have clear and up-to-date knowledge of regional and national industrial capabilities, which is currently often fragmented. This is also demonstrated by the third pillar of the Chips Act: while the need to accurately map individual national ecosystems is recognised, there is a lack of real capacity to collect and share information. Public authorities, not being an integral part of the value chain, depend on data provided by the private sector, which is often fragmented, voluntary and conditioned by trust in the system⁴³. In the absence of clear incentives and data protection mechanisms, the monitoring activity of the European Semiconductor Board remains weakened, compromising the effectiveness of the alert and forecasting system.

Given the multitude of factors that influence European decision-making today⁴⁴, a key priority should be to build a truly integrated European semiconductor ecosystem capable of overcoming national interests and strengthening Europe's position within global value chains.

41 Huggins, R., Johnston, A., Munday, M., & Xu, C. (2023). Competition, open innovation, and growth challenges in the semiconductor industry: The case of Europe's clusters. *Science and Public Policy*, 50(3), 531–544. <https://doi.org/10.1093/scipol/scad005>

42 Huggins R. (2022)

43 Kleinhans, J.-P., & Hess, J. (2022, September). Governments' role in the global semiconductor value chain. Stiftung Neue Verantwortung. <https://www.stiftung-nv.de>

44 Duchâtel, Mathieu. Semiconductors in Europe: The Return of Industrial Policy. Policy Paper. Paris: Institut Montaigne, March 2022. <https://www.institutmontaigne.org/en/publications/semiconductors-europe-return-industrial-policy>

3.2 SKILLS SHORTAGES AND TALENT RETENTION ISSUES

Specialised human capital is one of the most strategic elements of the entire semiconductor industry, a sector undergoing constant technological evolution. Globally, by 2030, over 1 million additional workers will be needed in the sector, while in Europe alone, the demand linked to growth and demographic turnover will exceed 271,000 open positions⁴⁵, most of which will be technical in nature.

Although the European Union is the world's third-largest producer of STEM graduates (1.13 million in 2022), only 28% specialise in fields relevant to semiconductors, and only 6% actually enter the European semiconductor industry. In addition, about 10% emigrate abroad, exacerbating this weakness⁴⁶. Another relevant aspect to highlight is demographics. The current workforce is ageing, with a third of workers in the US and Germany over the age of 55, and university courses are failing to provide adequate preparation for entry into the factory floor.⁴⁷ The time required to make a graduate fully operational remains long, and is often discouraging for both companies and young people. This is a global problem that has seen China, experience a shortage of over 300,000 specialised technicians, while in Korea the future demand exceeds 30,000 workers⁴⁸. Taiwan, South Korea, Japan and the US are also facing serious shortages. On the labour side, factory conditions are becoming less and less attractive to young people: long shifts, poor flexibility, uncompetitive wages and limited career prospects contribute to a high dropout rate, 53% turnover in 2024 in the US⁴⁹. Many graduates perceive manufacturing roles as unprestigious or incompatible with a good work-life balance. The case of the TSMC factory in Arizona is emblematic: despite billions in investment, the company struggles to recruit locally due to low wages, mandatory 18-month training in Taiwan, and a corporate culture perceived as hostile. These elements reveal a real cultural and generational gap that needs to be bridged⁵⁰.

In Europe, the number of graduates in key sectors is stagnant (estimated Compound Annual Growth Rate +1% to 2030), while industrial demand is growing at a rate of 5%, generating an annual deficit of approximately 3,830 unfilled positions and a cumulative gap of over 75,000 workers by the end of the decade⁵¹. The critical issues concern not only quantity, but also the quality of skills. There is a growing demand in the semiconductor industry for highly specialised figures, such as AI/ML engineers, neuromorphic computing experts, RTL designers, hardware-software integration engineers, chip-to-cloud security architects and digital twin specialists for the virtual development of SOCs. This generates an ever-increasing need for "unicorn candidates" capable of operating in multiple fields, but difficult to find and very expensive for companies⁵². European universities are also struggling to align themselves with the need for technical profiles, especially because many students do not have access to advanced software and industrial tools (e.g. EDA design tools for sub-2nm chips), especially in chip design courses, an area where Europe is most vulnerable⁵³. In recent years, numerous initiatives have emerged at national and European level. Universities such as KU Leuven have activated advanced master's degrees in Nanoscience and Nanotechnology in close collaboration

45 Daenen A. (2025) Europe's semiconductor boom 'risks stalling without skilled talent' <https://the-european.eu/story-50956/europes-semiconductor-boom-risks-stalling-without-skilled-talent.html>

46 Beaujeu et al., Addressing the talent gap in the EU Semiconductor Ecosystem, ECSA (2024) <https://chipsacademy.eu/wp-content/uploads/2025/05/ECSA-Skills-Strategy-2024-rev-20052025.pdf>

47 <https://www.semi.org/en/blogs/the-semiconductor-talent-crisis-why-growing-demand-cant-find-leaders>

48 Wassner et al. (2022), Reshoring Semiconductor manufacturing, addressing the workforce challenge, Center for strategic and international studies

49 Smits, J.-B. (2025). The semiconductor talent crisis: Why growing demand can't find leaders. SEMI <https://www.semi.org/en/blogs/the-semiconductor-talent-crisis-why-growing-demand-cant-find-leaders>

50 Damanpak Rizi, A., et al. (n.d.). From talent shortage to workforce excellence in the CHIPS Act era: Harnessing Industry 4.0 paradigms for a sustainable future in domestic chip production. University of Florida.

51 <https://chipsacademy.eu/wp-content/uploads/2025/05/ECSA-Skills-Strategy-2024-rev-20052025.pdf>

52 Agrawal, K. (2025). Billions of investment in advanced chips, but who will build them? <https://builtin.com/articles/semiconductor-manufacturing-skill-shortage>

53 Daenen A. (2025) Europe's semiconductor boom 'risks stalling without skilled talent' <https://the-european.eu/story-50956/europes-semiconductor-boom-risks-stalling-without-skilled-talent.html>

with industry; the Erasmus Mundus MSc in Nanotechnologies involves several European universities⁵⁴. At continental level, the European Chips Skills Alliance (ECSA) has funded summer schools (e.g. in Budapest), online courses, student communities and pilot projects with secondary schools. Micro-credential programs have also been introduced to upgrade skills in emerging sectors such as AI, machine learning and data analytics, but these tools are still little recognised at an interinstitutional level. These initiatives remain too fragmented and lack unified direction. The absence of strong European governance limits the scalability of solutions, while many industrial actors prefer to develop proprietary training programmes, avoiding contributing to shared ecosystems. These trends suggest the need to turn the strong European scientific base and existing training initiatives into a more coordinated talent chain. This involves improving access to advanced tools, better aligning education and industry, and enhancing, as well as retaining, the specialised profiles crucial to the semiconductor ecosystem.

3.3 HIGH DEPENDENCY ON FOREIGN SUPPLY FOR LOGIC AND MEMORY CHIPS

While Europe can boast established expertise in the upstream stages of the value chain, from academic frontier research to the production of highly specialised lithography equipment, it remains structurally weak in the realisation of finished products, particularly in the strategic segments of logic and advanced memory chips. It also holds less than 2% of the global testing market, with an almost absent presence in critical areas such as memory testing and wafer probing⁵⁵. The global semiconductor market is experiencing unprecedented growth, with an increasing emphasis on logic and memory chips. In the first half of 2025, the sector reached a value of \$346 billion, an increase of 18.9% over the previous year⁵⁶. This growth is fuelled by explosive demand for advanced chips for strategic digital infrastructure, particularly data centres and new edge applications of artificial intelligence. Europe is currently heavily dependent on foreign countries for these two types of essential chips. This deficit has led to increased dependence on foreign foundries, particularly Asian players such as TSMC and Samsung, which are global leaders in the advanced production of logic wafers in increasingly sophisticated technology nodes (7nm, 5nm, 3nm). The geographical concentration of these production capacities in geopolitically sensitive regions, such as Taiwan and South Korea, has raised serious concerns about the resilience of European supply. To address this critical issue, the European Commission has set out new ambitions through the Digital Compass 2030 programme, aiming to create 2-3nm production facilities within the Union⁵⁷. In addition, the 2022 European Chips Survey Report sought to map European industrial demand: it found that over 50% of wafers purchased come from non-EU countries, while 80% of materials are still silicon-based, a further indicator of structural dependence⁵⁸. This scenario raises an obvious problem: major European semiconductor companies appear to have underestimated the need to invest in their production capacity. As a result, there has been an increase in dependence on foreign foundries. In addition to this, the absence of a robust European consumer electronics industry has reduced the incentive to invest in the production of advanced logic chips. Many European companies have focused on sectors such as automotive and industrial, favouring product differentiation over miniaturisation (node reduction). This orientation has made investments in advanced technology nodes less advantageous, widening the gap with Asia and the United States. The accumulated delay makes it complex today to reduce Europe's dependence on advanced logic chips. But to give up bridging this gap would be to lose relevance.

54 Daenen A. (2025) Europe's semiconductor boom 'risks stalling without skilled talent' <https://the-european.eu/story-50956/europes-semiconductor-boom-risks-stalling-without-skilled-talent.html>

55 Bonnet, P., Ciani, A., Molnar, J., & Nardo, M. (2022). EU's strengths and weaknesses in the global semiconductor sector. European Commission, Joint Research Centre.

56 World Semiconductor Trade Statistic 2025 <https://www.wsts.org/esraCMS/extension/media/f/WST/7175/WSTS-Q2-Release-2025-08-04.pdf>

57 <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0118#:~:text=This%20will%20enable%20a%20society,in%20rural%20and%20remote%20areas>

58 EU Commission (2022), European chips survey report, Directorate-General for Internal Market.

4. Policy priorities and Strategic Recommendations

The following recommendations focus on three key areas: skills development and access to talent, strengthening European governance, and strategically repositioning Europe in global value chains. The proposals are based on the direct experiences of the actors involved and on good practices already tested at European and international level.

4.1 INVESTING IN SKILLS AND TALENT TO BUILD A SOLID INDUSTRIAL BASE

From operational profiles in foundries to R&D engineers, the lack of adequate skills slows down both innovation and production capacity. Several interviewees emphasised that the problem is not only quantitative but also qualitative, and concerns the growing gap between training and industrial needs.

- ④ Strengthen STEM education, starting in secondary schools, by updating curricula, methodologies and infrastructure, and promoting technical and vocational pathways related to microelectronics. A replicable example comes from Ireland, where over 370 future teachers took part in paid summer internships at tech companies: an experience that will potentially improve STEM education for over 1.5 million students. However, bringing this model to Europe requires better coordination between the education ministries of member countries, which is still too fragmented today.
- ④ Introduce agile tools for upskilling and reskilling the workforce, with micro-certifications recognised at European level, intensive courses co-designed by universities and industry, and incentives for student and professional mobility. To be effective, these initiatives must be officially recognised by companies and universities, and not remain isolated.
- ④ Improve migration policies to attract skilled non-EU talent, reducing barriers to entry and promoting initiatives such as Digital Explorers, to be replicated in other Member States. Some respondents also propose a specific “European Blue Card” for deep-tech sectors.
- ④ A further obstacle is the lack of industrial cooperation: major players often develop exclusive training programmes and are reluctant to participate in joint European forums, which they perceive as slow and fragmented. There is therefore a lack of a central structure, an “umbrella organisation”, to coordinate investment and align industry, universities and governments for integrated and synergistic training.

4.2 STRENGTHENING EUROPEAN GOVERNANCE AND REDUCING FRAGMENTATION

Many stakeholders highlight the challenges posed by the lack of truly unified governance at European level: Member States’ initiatives often run in parallel, leading to duplication, inefficiency and internal competition. The Chips Act is seen as a strategic opportunity, but it is still too focused on national interests and biased towards large companies.

- ④ Considering the forthcoming review of the Chips Act, solutions aimed at improving governance could be explored in the context of a Chips Act 2.0. In particular, the second pillar could be strengthened by introducing coordinated mechanisms that encourage cooperation, the participation of SMEs and

support countries with lower investment capacity. This review would be a crucial opportunity to define a more unified and effective framework.

- ④ Encourage the creation of interconnected regional industrial supply chains, supporting SMEs and innovation centres in currently marginal areas (e.g. Southern Europe), and promoting industrial alliances that bring together large players and new entrants. There are too many different platforms and calls that SMEs have to register several times, with slow and disorganised processes, a situation that can discourage startups and innovative actors, who often do not have structures dedicated to fundraising. Although startups and SMEs are included among eligible recipients, accessing the funds remains a complex and challenging process. This highlights the need for greater simplification, better coordination, and faster disbursement procedures to ensure that these innovative actors can fully benefit from available support.
- ④ The experience of projects like TwinE (Digital Twin for Europe), coordinated by the Fraunhofer Institute for Applied Information Technology, a €25 million initiative, largely funded by the Commission, aiming to develop a pan-European digital twin through a federation of local twins, highlights both the potential and the challenges of federated digital ecosystems. While the project embodies a strong pan-European vision, issues remain around synchronisation, standardisation, and uniformity of implementations across countries. To maximise the benefits of federated approaches in IPCEI projects and digital ecosystems like Digital Twin, it is crucial to establish clear EU-wide standards and harmonised implementation frameworks. Strengthening coordination mechanisms among Member States can reduce fragmentation, promote interoperability of skills and infrastructures, and avoid redundant investments. Investing in the development of interoperable, reusable infrastructure at the pan-European level will facilitate the scaling-up of digital ecosystems, unlocking their full potential across different sectors.

4.2 STRATEGICALLY REPOSITIONING EUROPE IN GLOBAL VALUE CHAINS

- ④ Relocating the entire production supply chain is unrealistic. Some interviews highlight that, despite European excellence in the production of equipment (ASML, AMLAS, Axel), large investments in plants (fabs) are moving towards China, putting at risk the maintenance of production capacities in the Old Continent. Therefore, it could be important to identify strategic choke points (e.g. back-end manufacturing, critical materials, test equipment) where Europe can have an advantage or strengthen its position, including through friend-shoring with trusted partners; Support the creation of shared testing and development structures at EU level, reducing the risk of duplication and fragmentation (e.g. common platforms for prototyping or advanced testing).
- ④ Given the potential for foreign suppliers, particularly from China, to engage in dumping practices with significantly lower prices, a phenomenon already observed in other sectors such as solar energy, it could be useful to strengthen cooperation at European level through a "chip diplomacy" coordinated between countries with similar interests, in order to strengthen the resilience of the internal market and support the growth of the sector.



5 Conclusion

Semiconductors are now one of the most strategic technologies for Europe and the world. The analysis of strengths and challenges of the European industry outlines a specific framework for Europe: its future is linked to the structural reality of global interdependence and the need to manage accelerated competition. The findings reveal key strategic assets and structural gaps: ASML's global leadership in EUV lithography, while dependent on European and International partners, illustrates the interconnection between European capabilities and international supply chains. The growing role of AI hardware, photonic chips, and wide-bandgap semiconductors demonstrates how applied research can become a lever for industrial growth. The presence of strong regional hubs, Minalogic, Silicon Saxony, High Tech NL, and initiatives such as STMicroelectronics' silicon carbide campus confirm the value of regional forces. At the same time, fragmented governance, duplication of funding, and the fragmentation of skills initiatives underline the strategic cost of disjointed action.

To convert current capabilities into structural success, the construction of a cohesive, pan-European strategic architecture is crucial. This also implies a unified governance to connect centers of excellence, implementing a coordinated human capital plan, and actively supporting the evolution of critical niches through applied research, thus creating a durable and strategic ecosystem.



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