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At a glance

Development of the German and European semiconductor ecosystem

What is this about?

The development of the semiconductor industry in Europe is under intensive discussion. Central technologies of the digital economy (telecommunications, cloud & edge computing, data centers, AI, high-performance computing, PCs) drive the digitization processes and determine how energy efficient and reliable they are. However, the demands of the digital economy for semiconductors in the current debates are not sufficiently reflected. Taking all relevant user industries into account is essential for a successful German and European semiconductor strategy.

Bitkom's view

Bitkom welcomes the existing and planned measures such as the currently advancing IPCEI Microelectronics and Communication Technologies II and the EU Chips Act as important foundations for strengthening the semiconductor ecosystem in Germany and Europe. A holistic perspective on the value chain and alignment with the strategic needs of user industries is crucial here. **Our goal** is to analyze and discuss medium- and long-term concepts for the development of the semiconductor ecosystem in Europe and Germany in the context of the digital decade.

Core Points

- **Investments in the entire semiconductor ecosystem to meet future user needs and to retain control and capabilities in relevant components**
  European demand for semiconductors in total and in particular for chips with smaller structure sizes is expected to grow rapidly over the next decade, driven by the further roll-out of digital infrastructure and the growing demands for computing power and communications in various industries. Thus, creating attractive framework conditions will be crucial to mobilizing investments that strengthen the whole value network and includes all relevant participants. Competencies in several key segments of the value chain should be built up, and reciprocal dependencies with international partners in the semiconductor value network should be reinforced.
- **Engaging more closely with the user industries of the digital economy**
  User companies from the digital economy should be strongly involved at an early stage in the conception of the respective funding measures. A structured ongoing dialog with user and supplier industries in Europe, including SMEs, about strategic qualitative needs and future requirements should be established.

Key Points

Key considerations for medium- to long-term developments of the German and European semiconductor ecosystem

January 10, 2022
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Current situation

The development of the semiconductor industry in Europe and the resilience of value chains in Europe and for European customers is presently under active and intensive discussion. There exist various avenues of action and activities which address both **short-term supply chain disruptions** and **long-term strategic needs**.

There is a strong focus in the public discourse on the needs of industrial production (Industry 4.0) and the automotive industry. The needs and challenges of the digital economy are currently inadequately represented in the debate. That applies in particular for the technology fields of connectivity (5G/6G), cloud & edge computing, data centres, artificial intelligence, high-performance computing together with personal computer and consumer electronics. These sales markets account for more than 75% of total turnover on the global semiconductor market, this share is with 37 % currently lower in the EMEA region.[1].

However, these technology fields are the driving forces behind digitalisation processes and among other things determine their energy efficiency, reliability, and trustworthiness. Not least against the background of the Digital Decade which is being promoted at EU level[2], the comprehensive digitalisation of all areas of life and the quest for digital sovereignty, they are assuming decisive significance. A focus on the needs of all relevant user industries is therefore the basis for a German and European semiconductor strategy and the derived avenues of action.

The current global shortage of chips has hit the digital economy hard. The consequences which companies within the supply chain have to confront are supply problems, late deliveries and higher prices which compound with complex production processes and are reflected in the prices paid by end users. The reasons underlying the present bottlenecks are complex and dynamic – with some bottlenecks changing on a weekly basis. In light of

[1] Semiconductor Industry Association: 2021 State of the U.S. Semiconductor Industry Report, World Semiconductor Trade Statistics
[2] Europe's Digital Decade: digital targets for 2030

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future developments in user needs in the digital economy over the medium and long term, it is important to exercise caution when interpreting the current bottlenecks.

The main purpose of this paper is to analyse and discuss medium- and long-term ideas and concepts for development of the semiconductor ecosystem in Europe and Germany in the context of the Digital Decade. The current bottlenecks and short-term solutions are not the focus of this publication.

Semiconductors for the digital economy in the Digital Decade

A broad palette of microelectronic components enabling a range of functionalities is used for applications in the digital economy. These include digital integrated circuits[3] for data processing, analog ICs for signal conversion and processing, and semiconductor memories.

The development of new-generation (5G/6G) **mobile communication networks** will drive demand for the corresponding microelectronic components which enable low latencies, high processing speeds and low energy consumption.[4]

The growth in **cloud services** and exponential increase in data volumes which have to be stored and processed are driving the demand for computing capacity and hence the market for chips for servers and IT infrastructure for **data centres and cloud infrastructures in Germany and Europe**.[5] To meet sustainability targets and to keep CO_2 emissions at a low level, it is important to reduce the energy consumption of these systems as much as possible, for instance through the use of energy-saving chips.

Furthermore, the demand for computing capacity and hence for specialised chips with an enhanced computing power and low energy consumption is increasing with the introduction and use of **artificial intelligence** technologies and the use of **high-performance computers** in businesses and academia for simulations, data evaluations and reliable forecasts in a range of industrial sectors.[6]

Although the development of **quantum technologies** is currently still at an early stage, a considerable economic benefit is enabled with the growing maturity of technological platforms and the development of industry-relevant use cases. Accordingly, it is today of

[3] In integrated circuits (abbreviated to IC), different microelectronic components (transistors, diodes, capacitors, resistors, etc.) are deployed on a semiconductor substrate and electrically connected. There are various kinds of ICs as a function of the task that they perform, e.g. memories, processors, microcontrollers, etc. Modern integrated circuits can comprise many hundred millions of components. In general speech, ICs are often referred to as chips.
[4] https://www.accenture.com/us-en/insights/high-tech/semiconductor-5g
[5] https://www.alliedmarketresearch.com/data-center-chip-market
[6] https://www.datacenter-insider.de/hpc-markt-starkes-wachstum-fuer-gpus-hpc-cloud-und-ki-systeme-a-1078851/

central importance to secure skills in design and production of the corresponding specialised microelectronic components and systems in order to prevent future dependencies in this area. By way of example, both obtainable materials for coherent calculations (Qubits) and the necessary interfaces with classical semiconductors as well as the possibility of their monolithic integration are strategically important for Germany and Europe in the area of **quantum computing**.

After the pandemic has driven millions of workers, students and consumers into the digital world, PCs have become more important than ever for productivity, fairness in education, remote medical care and the survival of small businesses. In order to cover the enormous demand and to underpin the supply of **PCs** in the future, equipment manufacturers need a stable supply of semiconductor chips from different technology generations.

Given the high computing capacity already needed and which is only likely to increase further in the future, e.g. also in **cars and driverless vehicles** as in other industrial sectors such as **industrial production (Industry 4.0)**, the corresponding processor and communication chips are needed here too.

In particular, digital integrated circuits for data processing need constantly improving production processes which enable smaller structure sizes of electronic components and hence a higher density on a single unit of area in order to meet high requirements on computing power and energy efficiency. The generations of semiconductor production processes are known as “technology nodes”: the smaller the technology node used in the production process, the smaller the semiconductor structures produced on the wafer. “Leading edge” is a term which often refers to the newest, most advanced technology node which allows the smallest structure sizes as well as the semiconductors they are used to make. In 2021, the term “leading edge” refers to node sizes of 10 nm, 7 nm and 5 nm, while 4 nm, 3 nm, 2 nm nodes are envisaged in the coming years. This approach is also known as “more Moore”, since it assumes an upscaling in accordance with Moore’s law.[7]

Another definition of “leading edge” also encompasses semiconductors with larger structure sizes but which enable new applications and advancements due to innovative materials, particular electrical or optical properties or the complex integration of different optical, electronic and other structural elements. As compared with “more Moore”, this approach is known as “more than Moore”. All of the said semiconductor categories are of great strategic relevance, since they are currently needed in certain application scenarios

[7] Moore’s law states that the number of transistors and hence the computing capacity on an integrated circuit doubles about every two years.

and will be in the future. For all these categories, stable market growth is expected in the years ahead.[8]

At the moment, three companies located in Asia and the United States are leaders in the "more Moore" approach[9], and also produce chips on a contract basis. Their customers are the so-called "fabless" companies which develop circuit designs for chips but do not carry out their own fabrication. Companies from the USA currently dominate the market for chip design, whereas companies from Europe have only a limited market share. Companies from Europe concentrate mainly on the development and production of semiconductors under the "more than Moore" approach.[10,11]

Central challenges for Europe and Germany consist in covering future demand for semiconductors from relevant user industries and to secure supply. In this regard, Europe and Germany should maintain the ability to act on a sovereign basis in the framework of a closely intertwined global value chain. That means both having own high-level capacities in Germany and Europe in central technology fields and services and being able to choose autonomously and confidently among alternative offers from competent and trustworthy partners.

In the "2030 Digital Compass"[12], the European Commission has declared a doubling of the EU's share in worldwide production of advanced and sustainable semiconductors to be an important objective. **Whereas the production share is an important indicator of development in the semiconductor industry, it is insufficient to obtain a holistic overview of digital sovereignty and resilience without taking the total ecosystem and overall value chain into consideration**.

The semiconductor industry is characterised by a highly complex value chain which broadly comprises three main steps: **chip design**, **wafer fabrication (front-end process)** whereby the semiconductor structures are deposed on silicon wafers in several steps and a **back-end process** in which the individual chips are fitted with electrical contacts and packaged to prevent physical damage and corrosion. Each of these steps is in turn supported to a great extent by a complete ecosystem of supplier industries. For example, these may offer licences for microprocessor architectures and software tools for chip design, raw materials and wafers, liquid chemicals and gases for diverse process steps

[8] WSTS Semiconductor Market Forecast Fall 2021
[9] WikiChip: Technology Node
[10] Stiftung Neue Verantwortung, Jan-Peter Kleinhans "The lack of semiconductor manufacturing in Europe"
[11] Semiconductor Industry Association: 2021 State of the U.S. Semiconductor Industry Report
[12] Europe's Digital Decade: digital targets for 2030

such as coating, etching and cleaning, and special high-tech equipment for both front-end and back-end processes.

In this respect, no region of the world is able to control the entire value chain on its own. The ability to act sovereignly calls for the development of competencies and an increase in the market share in several key segments of the value chain as well as a strengthening of reciprocal dependencies with important partners.

Various existing policy measures are intended to promote development of the semiconductor ecosystem in Germany and Europe. For the first time, the first IPCEI on microelectronics enabled direct allocation of state aid for promotion of innovations in the microelectronics sector through to first industrial deployment.[13] The second IPCEI on microelectronics and communication technologies (IPCEI ME / CT)[14] will build on this progress and extend it to the area of communication technologies. The European industrial alliance on processors and semiconductor technologies seeks to establish a structured dialogue between policy-makers and industrial players in Europe and to strengthen cooperation between user and supplier industries.[15] The EU Chips Act announced for 2022 sets out to create a policy and financial framework for promotion of the semiconductor ecosystem in Europe.

The following points describe the aspects Bitkom deems important for deliberations on the shape of policy action avenues in the area of semiconductors. The general idea is that strengths should be strengthened, and weaknesses reduced.

1. Within the global semiconductor ecosystem, Europe and Germany already occupy a stronger position in several sectors and for particular technologies. This relates in particular to development and production of application-specific chips with larger node sizes (for example 10 - 22 nm). European companies also play an important and sometimes indispensable role on the world market in areas such as plant construction as well as production of wafers, raw materials and chemicals. To maintain and develop digital sovereignty in the area of semiconductors, it is therefore essential further to strengthen European know-how in these areas and to foster cooperation with global partners. In future, the digital economy will need a broad spectrum of semiconductors, also including mature technologies.

   Nevertheless, for semiconductor chips with node sizes below 10 nm, the needs of user industries in Europe are currently filled to a large extent from production capacities

[13] https://www.bmwi.de/Redaktion/DE/Artikel/Industrie/mikroelektronik.html
[14] BMWi: Bekanntmachung einer Interessenbekundung zur geplanten Förderung von Forschungs- und Investitionsvorhaben im Bereich Mikroelektronik und Kommunikationstechnologien
[15] Alliance on Processors and Semiconductor Technologies

outside the EU. In addition, the design of these advanced microelectronic components is developed by companies outside the EU with just a few exceptions. With the further development of European digital infrastructure as well as in other industrial sectors with increasing processing power and communication requirements, (Industry 4.0 and connected production), it can therefore be expected that the demand for semiconductors in Europe will double over the next ten years and that chips with structure sizes of less than 5 nm will account for around 40% of total demand.[16] To be able to cover this user demand and at the same time maintain control over the components used (e.g. through the design of secure microelectronics and patent protection for the algorithms used), investments in the semiconductor ecosystem generally and particularly in relation to chips with the smallest structure sizes are indispensable today.

2. Given the technological complexity of the value chain and economic viability, companies around the world tend to specialise on a particular sector of the value chain or a particular technology and develop innovations there. This has led to multifaceted dependencies on the global semiconductor market so that companies and world regions are highly reliant on global partnerships and open economies and markets. Current gaps in the value chain can be exploited by other governments through export controls which restrict access to important technologies. Increasing geopolitical tensions between the USA and China pose a risk for supplier and user industries in the semiconductor sector in Europe, since these could make access to particular technologies and markets more difficult. Moreover, "unforeseeable" crises such as pandemics or natural catastrophes can disrupt supply chains for important semiconductor technologies temporarily or even permanently.

Assessment of and perspectives for existing European structures

3. The first IPCEI on microelectronics broadly proved itself[17] to be an effective instrument for allocation of state aid for carrying out innovative projects and development of the semiconductor ecosystem in Europe. The planned second IPCEI on microelectronics and communication technologies should move this development forward and close the remaining strategically relevant gaps in the European value chain. It is of decisive importance in this regard both to help close the supply gap in relation to more mature technology nodes and to take aim at the increasing future demand of user industries in Germany and Europe for node sizes below 10 nm. This means above all that the future requirements for key technologies such as 5G and 6G

[16] Kearney Report "Europe's urgent need to invest in a leading-edge semiconductor ecosystem"
[17] Further development of the state aid instrument is currently under way and welcome: https://www.bitkom.org/Bitkom/Publikationen/Roadmap-Revision-of-Communication-on-IPCEI

or cloud and artificial intelligence need to be taken into account. As part of ongoing digitalisation, 5G and 6G technologies are increasingly penetrating all areas of the economy and pushing demand for components with structure sizes below 10 nm well above needs that can be seen today.

4. The European industrial alliance on processors and semiconductor technologies is an important initiative for establishing a structured exchange between user and supplier industries in Europe. It is important in this respect not only to address the current disruptions in the supply chain but also in particular to identify weaknesses in the value chain with regard to future qualitative needs. The joint declaration by 22 Member States on the European initiative on processors and semiconductor technologies[18] is an essential step to strengthen European cooperation in the semiconductor ecosystem for the upscaling and modernisation of production for semiconductor technologies, in particular for smaller technology nodes.

Our recommendations for Germany and Europe

5. An ongoing structured dialogue with user and supplier industries in Europe including SMEs on strategic qualitative needs and future requirements in Europe should be established in the framework of IPCEI ME / CT and the European semiconductor alliance.

6. The semiconductor ecosystem should be promoted holistically along the value chain. The focus should be stronger on strategic user needs of the digital economy generally.

7. The rapid growth in demand for semiconductors in Europe over the next decade will be driven to a large extent by the technologies of the digital economy. The EU Chips Act should support the development of semiconductor production capacities in the European Union and tie in with existing structures and projects such as IPCEI ME / CT or the European semiconductor alliance. Continuous funding structures should be introduced which go beyond financing of first industrial deployment and also encompass modernisation of production and expansion of capacity. Efforts should concentrate on long-term capacity development instead of diagnosing specific product deficits by type or company.

   This needs a twin-track approach: first, a strengthening of the supply of technologies which are already available and are expected to be in demand in Europe for many years more; and second, formulation and implementation of a strategy for semiconductors with smaller structure sizes in order to be able to cover comprehensively the long-term needs of the digital economy.

[18] Joint declaration on processors and semiconductor technologies

In addition, the development of design skills in Europe for the newest chip technologies is also of decisive importance for critical ICT infrastructures to safeguard European patents and ensure access to secure chip technologies also in a fabless approach. Faster processes and de-bureaucratization would be appreciated for both new and existing funding programs. The IPCEI instrument should be continuously further developed in order to adapt it to the needs and speed of the digital economy.[19]

8. For the orientation of policy action avenues, maintenance of an open global ecosystem should be at the centre of considerations. Here, it is important to pursue a multilateral approach in order to intensify cooperation and reciprocal dependencies with trustworthy international partners in regions with relevant activity in the semiconductor value network.

9. A strengthening of the semiconductor ecosystem and ICT supply chains in the broader sense in Europe and Germany should be brought about through a mobilisation of investments in Europe and Germany, above all through attractive framework conditions for both supplier and customer industries. Attractive energy prices, working conditions and tax incentives are important aspects to take into account here.

10. The availability of skilled workers in a range of STEM disciplines can be an inhibiting factor for the necessary comprehensive development of the semiconductor ecosystem. Accordingly, the corresponding training and graduate study courses at European universities, technical colleges, and research centres as well as training in companies should be promoted.

[19] https://www.bitkom.org/Bitkom/Publikationen/Position-Paper-on-the-Revision-of-Communication-on-IPCEI