EXPERTENKREIS TRANSFORMATION DER AUTOMOBILWIRTSCHAFT

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RESILIENT SUPPLY CHAINS, EUROPEAN PRODUCTION CAPACITIES AND SKILLS DEVELOPMENT

Recommendations for a secure supply of semiconductor components to the German automotive industry

1 Summary

Semiconductor components are increasingly important for the reliable production of vehicles and represent a growing proportion of value creation in vehicles. But the value chain that results in the finished chip consists of a complex global network. Individual links in this value chain are dominated by a small number of companies. It will never be possible for a single country to cover every section of the value chain with domestic manufacturing, entirely avoiding dependency on other countries. At present, geopolitical tension threatens seamless production processes.

In this context, the Expert Group on Transformation of the Automotive Industry has formulated a realistic target situation for Germany and Europe: the goal is to ensure robust supply chains with acceptable risks. To achieve this, the Expert Group recommends the following actions in particular:

- The automotive industry should draw up long-term supply contracts and improve cooperation and planning throughout the value chain.
- Policymakers should create a positive climate for private investment and the creation of clusters in Germany by means of stronger university and vocational training programmes, lower-priced energy, sufficient water supply, and subsidies, including for basing businesses in Germany.
- Production at all stages of the value chain and of all types of semiconductor (mature, state-of-the-art and leading nodes) is welcome in Germany and in Europe. However, investment in semiconductor production should focus in particular on:
  a) Production of chips that are in high demand in the automotive industry, the manufacturing of which is currently extremely concentrated in the People's Republic of China and the production of which could realistically be relocated to Germany ➔ Frontend fabs and backend fabs for mature nodes and state-of-the-art nodes.
  b) Parts of the value chain that are of strategic importance to the automotive industry and that are in a good starting position in terms of international competition → Chip design, RISC-V microcontrollers/open-source architecture, sensors, power semiconductors, and EUV lithography.

2 Current situation

2.1 The importance of semiconductor components is increasing rapidly

Semiconductor components can have a wide range of functions. The dimensions of the elementary basic functions (e.g. transistor channel length; width and spacing of interconnects on the chip (also known as node size)) are given in nanometres (nm). The smaller the node size, the more transistors, and therefore the more functions, fit on a single chip. This means that the processing power of chips is increasing, as is their energy efficiency. Node sizes of 90 nm and larger are known as mature nodes, while the term leading nodes refers to technology nodes of 10 nm and smaller. The nodes between the two are known as state-of-the-art nodes. Power increases in state-of-the-art nodes and leading nodes are mainly achieved by shrinking the transistor size. In mature nodes, both the architecture of the power transistor and the semiconductor host material used play a decisive role. The various node sizes are used for different purposes: mature nodes encompass power semiconductors for controlling electrical energy, among other things; state-of-the-art nodes can serve as microcontrollers for the provision of processing power or sensors; while leading nodes are used for autonomous and connected vehicles, artificial intelligence, and infotainment applications, among other things.

The ramping up of electromobility (where semiconductors are used in both powertrains and in charging infrastructure), the development of autonomous vehicles, and the growing demand for infotainment systems mean that demand for semiconductor components is skyrocketing. Alongside the demand for greater quantities of semiconductors, demand is also increasing in terms of performance. Power electronics and high-performance computers are increasingly becoming strategic components in software-defined electric vehicles. This means that high-performance chips are essential in highly automated vehicles, so that large data volumes can be processed in real time.

The automotive industry currently depends in particular on mature nodes, which are expected still to account for more than half of total demand by 2030. However, the demand for higher processing power means that leading nodes and state-of-the-art nodes will also increase in importance.

2.2 The chip crisis and supply risks indicate that there is an immediate need for action

At the start of the COVID-19 pandemic, lower demand for vehicles and potential production stoppages led some companies in the automotive industry to reduce their orders for semiconductor components. When the demand for vehicles increased again shortly after that, the manufacturing capacity that had been freed up had already been assigned to other sectors, particularly consumer electronics.[1] The qualification processes necessary for the manufacture of semiconductor components to be used in vehicles meant it was difficult to find alternative sources. The limited share of the automotive industry in the semiconductor component market, with a total global share as low as around 10% of mature and state-of-the-art nodes and 1 to 2% of leading nodes, made it even more difficult to access these components.

[1] See https://www.digital-chiefs.de/chipkrise-gruende-auswege/

However, the current semiconductor supply situation is not a temporary shortage. Between now and 2030, demand from the automotive industry will roughly triple. This additional demand applies to mature nodes, state-of-the-art nodes, and leading nodes, although to different extents. Current existing and planned global capacities are insufficient to meet future requirements.

One risk for future supply is the extreme concentration of semiconductor component production among a small number of manufacturers. In addition, the geopolitical and security policy strategies of various governments mean that, on the global market for semiconductor components, market mechanisms are not functioning as they should. Individual countries influence the complex value network with subsidy programmes, protective tariffs and bans on imports. In the case of mature nodes, some 80% of new capacity around the world is in the People's Republic of China. The expansion of production capacity is underpinned by a comprehensive investment programme that will be continued in the coming years. It should also be noted that the automotive market in China is six times as large as in Germany and is also growing more rapidly. This concentration is problematic because the People's Republic of China could apply supply stops and import or export limits to semiconductor components and semiconductor host materials as a means of political pressure. The fact that this is a real threat can already be seen in the current trade dispute between the People's Republic of China and the USA. In the case of leading nodes, the concentration of the supply of semiconductor components in Taiwan is also considered a strategic risk. TSMC and Samsung are the only remaining providers of leading nodes. Intel has explicitly stated its goal of entering the market as the third contract manufacturer.

We must also look at the necessary raw materials if we are to obtain a comprehensive overview of the semiconductor value chain. This market is also characterised by dependencies and global imbalances (see the ETA short paper on the supply of critical raw materials).

2.3 European Chips Act to strengthen Europe's digital sovereignty, competitiveness and resilience

The European Chips Act was passed with the aim of strengthening Europe's digital sovereignty, competitiveness and resilience. It is intended, among other things, to foster research, innovation and design skills in the field of semiconductors, and to contribute to security of supply by providing a regulatory framework that will promote the establishment of semiconductor production facilities. A coordination mechanism for monitoring market developments is to be set up by the Member States and the European Commission, enabling crisis prevention. The aim of the European Chips Act is to double the European market share of global semiconductor manufacturing to 20% by 2030.

3 Target

These recommendations for action aim to make the supply of semiconductor components to the automotive industry more resilient in all three node categories. The goal is therefore to achieve robust supply chains with reasonable risks. This is critical for the automotive industry, given that the demand for semiconductor components is set to increase in future and in view of existing geopolitical risks. More resilient supply chains mean that the European economy cannot be put under pressure by political actors in a context of geopolitical conflicts.

4 Key action areas

4.1 Improving planning and cooperation

4.1.1 Improved management based on knowledge of upstream value creation stages

A key task for businesses in the automotive industry is to improve their understanding of the complexity of the semiconductor manufacturing chain and of their own role vis-à-vis their suppliers. It is particularly helpful for this analysis if these businesses have a knowledge of the sectors and technologies they are competing with to access the necessary semiconductor components, and what the demand cycles of these sectors and technologies are. If businesses also have this knowledge for upstream products, this further improves the quality of information available to them and can lead to more beneficial agreements with suppliers.

4.1.2 Closer partnerships throughout the supply chain

The companies in the automotive industry currently respond to dependencies in the supply chain by entering into long-term supply contracts for large numbers of units. To safeguard production in the short term, experts advise that companies in the automotive industry keep large stockpiles available. To ensure a return to reliable supply chains, automotive manufacturers should step up communication with semiconductor manufacturers. To be able to coordinate supply and demand more precisely and with better predictability, greater use should be made of capacity reservation agreements.

4.1.3 Cooperation with other sectors to avoid market risks

Semiconductor factories (both frontend and backend) do not exclusively manufacture products for the automotive industry. While suppliers enjoy a broad output market for their products, little has been done on the demand side up to now to exploit the potential of bundled demand volume, which would increase precision of demand and reduce the bullwhip effect. To do this, businesses should establish multi-company cooperation arrangements, processes, and platforms. Examples of this that are already in place are the KDT SC4EU project (the follow-up to SC3[2]) and the support of the IAF (Industry Advisory Council).[3] The

[2] See https://sc3-project.automotive.oth-aw.de/
[3] See https://www.semi.org/en/news-media-press-releases/semi-press-releases/new-semi-industry-advisory-council-to-advance-an-agile-resilient-global-electronics-supply-chain

applicable antitrust legislation must strictly be considered in such initiatives, as it is also important to protect demand-side competition.

4.1.4 Increased resilience through strategic alliances

In the context of the trade dispute between the USA and the People's Republic of China, the USA is seeking to cooperate more closely with Taiwan, Japan and South Korea through the Chip 4 Alliance. Europe is currently only considered a relevant player thanks to lithography system manufacturer ASML. Existing European strengths in the fields of power semiconductors, semiconductor sensors and microcontrollers should be reinforced and appropriate communication measures should be taken in order to secure discussions on an equal footing with the leading semiconductor manufacturing nations, with the aim of creating a strategic alliance.

4.2 Creating a positive climate for investments and clustering

4.2.1 Creation of a positive climate for investment

Expanding European manufacturing of semiconductor components will take time, effort and investment. Establishing an ecosystem of this type calls for a comprehensive approach, with the involvement of policymakers and the relevant industries. In general, attractive conditions such as reliable low energy costs and the availability of water must also be guaranteed.

4.2.2 Strengthening of education, training and research

Germany needs an attractive microelectronics ecosystem that encompasses the research community and skilled professionals and brings together users and manufacturers of semiconductor components. Joint R&D projects run by stakeholders from different parts of the semiconductor value chain, as well as by universities, offer the potential to strengthen technological sovereignty.

Training skilled professionals for the semiconductor component labour market is essential in view of the growing demand for semiconductors as a key element in vehicles. This calls for universities with suitable facilities, attractive courses of study, and occupational training, but, first and foremost, for a targeted range of education and training courses. Without the necessary skilled professionals, it will be difficult to achieve the anticipated growth in semiconductor component manufacturing.

4.3 Targeting investment at strategic areas

4.3.1 Strengthening of strategic areas with targeted investment

Production throughout the entire value chain and for all types of semiconductor (mature, state-of-the-art and leading nodes) is welcome and desirable in Germany and in Europe: from building up expertise and intellectual property in chip design and EDA software, through preliminary products (blank wafers, consumable materials, and chemicals), epitaxy (monolayer growth of crystalline material), wafer frontend processing, backend processing, testing, and cleanroom machines for frontend and backend, to cleanroom technology.

However, the idea that an entire semiconductor production ecosystem can be created in Europe is not realistic. For example, it is highly unlikely that the leading manufacturers of frontend leading nodes, leading packaging or DRAM will relocate to Europe, or that Europe will be able to build up its own expertise.

Investment should therefore be targeted at the following two areas:

Firstly, support should be given to the manufacture of chips that are in high demand for the automotive industry and other sectors, where there are high levels of dependency on the People's Republic of China, and where it is realistic that companies may relocate to Germany and Europe. This applies in particular to frontend fabs and backend fabs for mature nodes and state-of-the-art nodes.

However, if the One China Policy were to be implemented, the EU would be in a considerably worse position in relation to the People's Republic of China and would experience a crisis in the supply of semiconductor components.

Secondly, support should be given to those parts of the value chain that are of strategic importance and, at the same time, are in a good starting position in terms of international competition. These include chip design, RISC-V open-source architecture, sensors, power semiconductors (for example improved properties of silicon carbide semiconductors), and EUV lithography. Other countries are dependent on Europe in the areas of EUV lithography, semiconductor sensors, and microcontrollers. Funding should therefore be invested with a view to expanding Europe's existing strengths in order to ensure that other states remain dependent on the EU, which will maintain the balance of dependencies.

The European Chips Act represents an initial measure aimed at strengthening the European semiconductor industry. The funds available to subsidise relocation to Europe should be targeted to those areas where there will be the greatest impact in terms of increased resilience and strengthening of value creation in Europe. It is therefore important to carry out regular comprehensive analyses of the semiconductor component value chain so that, if necessary, subsidy programmes can be adjusted. Investment in frontend fabs has the potential to significantly reduce supply risks for European and German companies. State subsidies should serve first and foremost as an incentive for private investment through cooperation between companies in the automotive industry and manufacturers of semiconductor components. This build-out has considerable lead times and requires high levels of investment that must be decided in the short term.

4.3.2 Strengthening of local semiconductor development skills

There is major potential for European providers and technology suppliers to take up key positions in the field of design within the semiconductor component development and production chain. In terms of supporting software tools (EDA), there is currently dependency on the USA. The priority in this regard is not on increasing manufacturing capacities, but on building skills and intellectual property and on the creation of suitable development tools by universities, non-university research facilities, and industrial research.

4.3.3 Skills-building in RISC-V open-source architecture

RISC-V open-source architecture is on the verge of becoming a de facto industry standard. This flexible instruction set architecture can be used in microcontrollers, central computers, zone controllers, and in sensors with measurement value evaluation (smart sensors). One goal should be to establish an ecosystem based on this open-source intellectual property.

In addition, industry-wide standard-setting, for example for chiplets, could increase the interchangeability and the compatibility of chips made by different manufacturers. Improving the alternative options in this way would reduce direct dependencies on individual manufacturers. In the case of chiplets, instead of a single, monolithic chip, several easier-to-produce parts of a semiconductor component are connected using a

modular approach. The use of chiplet technologies could also enable synergies to be achieved among different user industries, such as computing, telecommunications, etc. In addition, software could also be designed independently of hardware, reducing dependency on specific chips.

4.3.4 Strengthening of production engineering skills

The association consisting of ASML, Trumpf and Zeiss puts Germany and Europe in a leading position in EUV lithography, which is a decisive element of semiconductor component production technology. This European expertise is unique and there will be no way of replacing or emulating it in the foreseeable future. This creates a strategically important dependency of other economic areas on Europe. It is therefore important to protect this expertise and to expand it with ongoing research and development activities and, on this basis, future investments.

5 About the Expert Group

In summer 2022, the Federal Ministry for Economic Affairs and Climate Action created the Expert Group on Transformation of the Automotive Industry (ETA). The ETA studies medium- and long-term challenges facing the automotive industry, and develops target-driven, tailored recommendations for action for policymakers, industry and society. By doing this, it aims to help demonstrate how barriers to transformation can be dismantled and how the automotive industry can harness the opportunities offered by this transformation. The cross-cutting aim is to achieve climate neutrality and at the same time to safeguard value creation, jobs and trainee positions in Germany's automotive industry.

One of the most important challenges facing the automotive industry at present is ensuring a secure supply of semiconductor components. In this context, it is important to consider both current supply chains and the future development of these in view of the increasing use of digital technology in vehicles. For this reason, the members of the Resilience and Smart Car ad hoc groups have joined forces with other experts in the field of microelectronics to take stock of the current situation and to discuss the options for action with a view to ensuring the ongoing supply of semiconductors.

Two joint workshops of the Resilience and Smart Car ad hoc groups took place on 23 March 2023 and 5 May 2023 to compile this short paper. A previously published short paper on Initial Action Areas to Strengthen the Resilience of Automotive Supply Networks was also used as a further basis for research. The ETA project office wrote this short paper. It was reviewed in the Resilience ad hoc group and in the Smart Car ad hoc group.