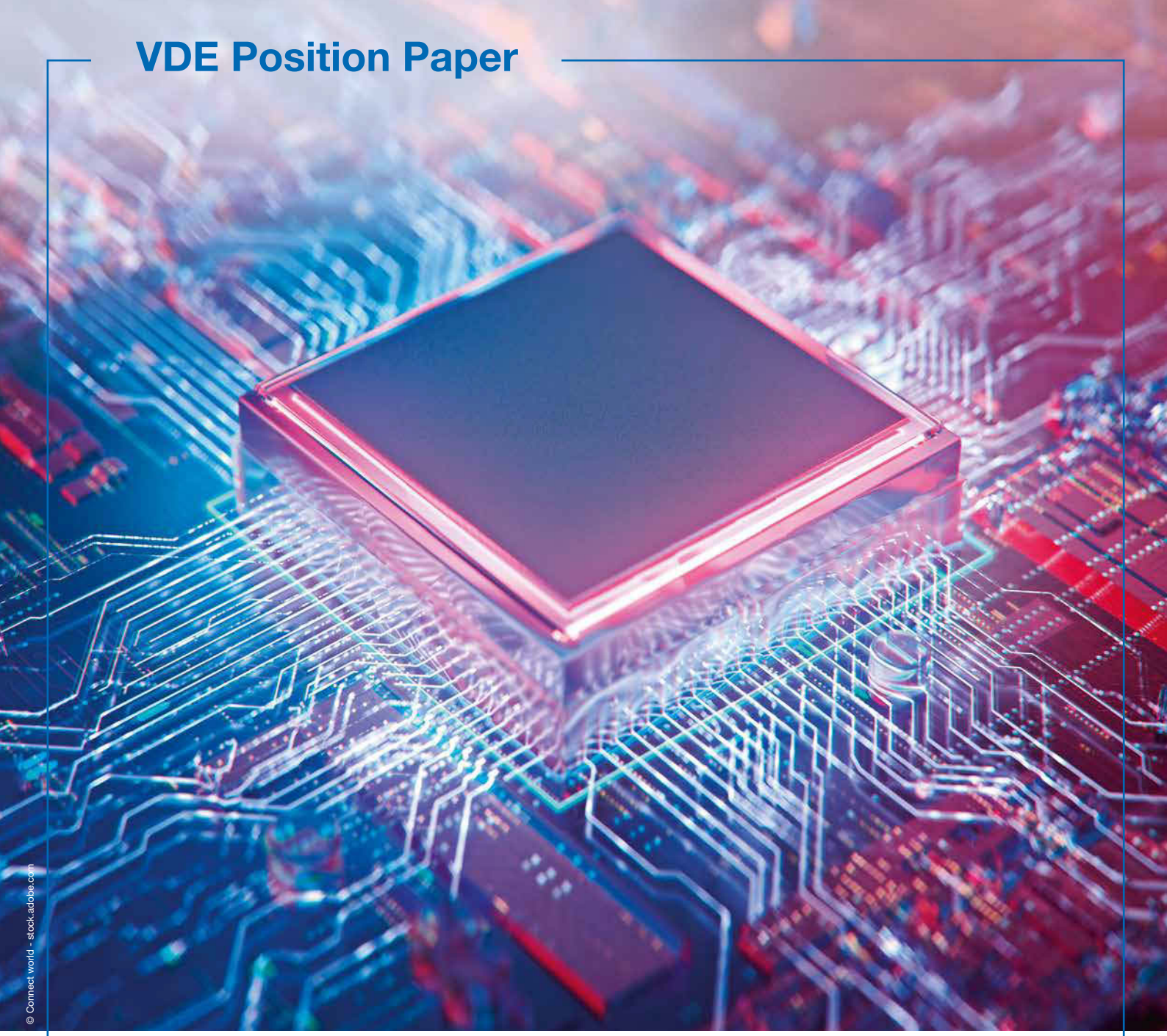
VDE Position Paper



Hidden Electronics II

A white paper on the Future of Semiconductor Technology in Germany and Europe

VDE VDI GMM and VDE ITG

VDE

About VDE

VDE, one of the largest technology organisations in Europe, has stood for innovation and technological progress for more than 125 years. VDE is the only organisation in the world that unites science, standardisation, testing, certification and application consulting under one roof. The VDE mark has been synonymous with the highest safety standards and consumer protection for 100 years. We advocate for the promotion of research and young talent and life-long learning with on-the-job continuing education offers. 2,000 employees at more than 60 locations worldwide, more than 100,000 volunteer experts and around 1,500 companies in the VDE network are creating a future worth living: networked, digital, electric. We are creating the e-digital future.

The VDE (*Verband der Elektrotechnik Elektronik und Informationstechnik e. V.* – Association for Electrical, Electronic & Information Technologies) is headquartered in Frankfurt am Main. More information at www.vde.com.

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Why another white paper on semiconductors?

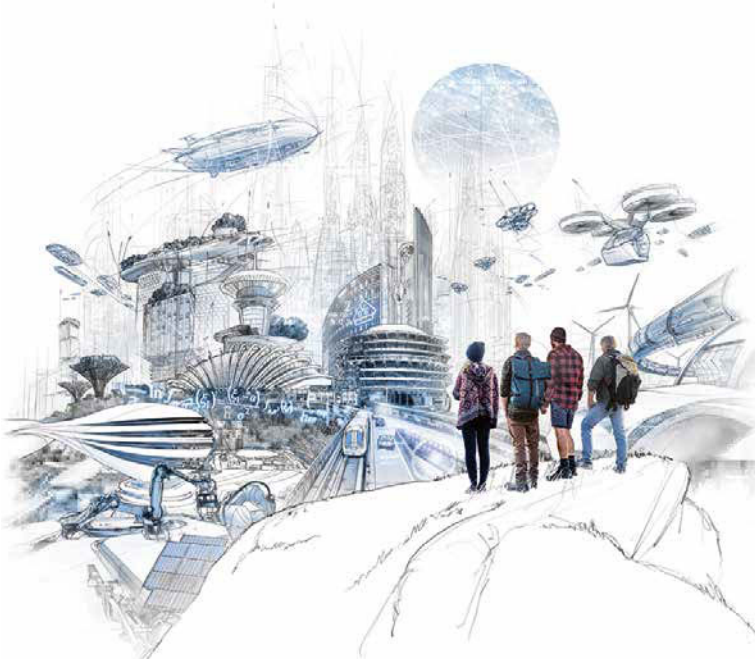
In April 2014, a group of VDE members wrote the German white paper Hidden Electronics which referenced the fundamental significance of semiconductor devices and circuits. A lot has changed since then: microelectronics was added to the German federal government's high-tech agenda and the IPCEI on Microelectronics programme was started at European level. This was also flanked by the modernisation of the infrastructure within the German Microelectronics Research Factory (FMD) and the German Microelectronics Research Labs (ForLab). These efforts are honourable, but by far not sufficient in the context of a future compatible microelectronic fabrication.

However, it would be a mistake to lean back and say, "Great, that went well". The rest of the world was not just watching to see how Germany and Europe promote their technologies; it also implemented wide-scale master plans, often with significantly more resources than in Germany. We may not like it, but China has long since ceased to be a follower in that and is now a leader. Moreover, we also cannot be content with the fact that Europe has slid down a few percentage points in the past few years with respect to semiconductor production compared to the rest of the world. Currently, we are facing another serious problem in addition to the tendency of production capacities being relocated. We are facing a serious risk as the open market and thus free access to every product and raw material might be restricted by the geopolitical situation. A few years ago, we still firmly believed we would be able to procure semiconductors from manufacturers around the world, but recent history has taught us otherwise. The USA is blocking the Android operating system for Huawei, China is using rare earth to build up economic supremacy, just to name two examples. In a factual assessment of the situation,
we unfortunately have to admit: The measures taken in Europe to promote semiconductor technology were adequate and necessary, but in comparison to the pace in the USA and Asia they are far too timid and not sufficient. The current major investments to promote digitisation, for instance in the field of artificial intelligence or quantum technology engineering, are headed in the right direction. We have to support the development of semiconductor fabrication with additional investments in order to promote young talents and new industry. Electronics, including the development and manufacturing of both hardware and software, often makes the difference in innovation required to release important products and services. One must assume that Europe will become more and more dependent on overseas countries with respect to the supply of semiconductor devices and electronic systems. This makes the entire European economy more and more vulnerable.

The COVID-19 lockdown in early summer of 2020 made clear to the global population how important communication media are and thus the possession of and ability to use electronic systems. The technological sovereignty of industrial countries and the security and reliability of these electronic systems are often referenced in this context.

In this paper, the authors discuss the central arguments of the Hidden Electronics white paper and, in light of the developments of the past few years, summarise the current state of the fabrication of semiconductors. The authors stress the economic and social significance of future fields of application of electronic systems and provide political and economic decision makers with clear arguments to strengthen and reinforce the field of semiconductor fabrication in Germany.

We have to act now!



Where does Europe currently stand in the field of microelectronics?

Semiconductors on the global economic level, is part of a continuously growing market which, like other markets, is also subject to fluctuations and the relatively mature industry still generates approximately 6% growth annually, even today. Germany, with its many small, medium and large companies, the FMD, research institutes and universities, active along the entire semiconductor value chain, is one of the largest and most innovative locations in Europe; its innovation potential is represented by being in fifth place in patent registrations behind Japan, China, the USA and South Korea. The German share of the global market is around a third of the total EU share, but Europe currently only holds a total share of just under 10 percent. With its global market share of approximately 3.3%, which has not changed significantly for a long time, Germany is far below the shares of the global leaders China (35.1%) and the USA (19.0%). With respect to per capita use of electronic products, Germany is in third place with US$ 187 billion, behind Japan (US$ 287 billion) and the USA (US$ 219 billion).

A detailed look at the individual segments like storage, logic, analogue, power electronics, sensors and optoelectronics shows that they are growing heterogeneously and are controlled to varying degrees by the three major global regions (America, Asia and Europe). While there is a consistently high demand for memory and logic chips, Germany is currently very strong in producing sensors and optoelectronics with above-average growth. The per capita demand for integrated circuits (ICs) in the global population increased from 8 in the 1990s to 39 in 2019, which is a significant increase. In 2019 alone, 290 billion ICs were produced. Since a continuously increasing portion of the global population is gaining access to consumer electronics, the trend continues.

A look back at the beginning of the century tells us that the regional distribution of the market shares between Europe, Asia and America was subject to massive redistribution where countries like China, Taiwan and South Korea have systematically set up their own microelectronics industries with long-term master plans. The difference between Europe and China is highly significant because, while Europe has successively lost market shares every year, the trend in China is continuously increasing. China has dominated the market for a few years and is now the largest buyer country for electronics. An estimate of the next four years also indicates expected further growth in semiconductors from currently more than US$ 400 billion to more than US$ 500 billion, whereby a total market value of more than 30 percent is expected for China alone. For comparison: Europe's share will be less than 10 percent, according to forecasts. The look at the fields of application of semiconductor devices and circuits with respect to the development of the global market shares from the start of the current century is extremely interesting. The classical share of computers and consumer electronics has decreased significantly. At the same time, sectors like automotive, industrial applications (IoT) and communications technologies (ICT) are increasing significantly. The growing market share of applications in the field of private and public administration and in the field of government organisations should also be considered. This is particularly prominent in the USA, while Europe is important in the automotive sector and China in the ICT sector. What is particularly impressive is the comparison of semiconductor production in the past five years: While companies in the USA have the lead with more than 50 percent of total production, China, Taiwan and South Korea together hold the lead in front-end production in foundries with almost 60 percent. More than half the capacity for advanced leading-edge technologies for structures under 18 nm is in Taiwan and South Korea. Although there are now nearly no leading-edge technologies in Europe, the Europeans consume around a third of semiconductors manufactured in these technologies.

Europe's strengths in the field of semiconductors come from companies like Infineon Technologies, ST Micro-electronics and Bosch. Europe can also stand its ground with respect to analogue components that often require a high level of customisation. Europe is also in a very strong position with respect to the production of components and systems in optoelectronics and sensors. Large portions of the manufacturing equipment for realising leading-edge technologies are developed in Europe, for instance, in the field of photolithography for nanoscale structures, where German and Dutch firms (Zeiss, Trumpf, ASML) lead.

Another of Europe's strengths is in the field of embedded systems. Manufacturers like Bosch should be mentioned here, as well as several medium-sized companies. In this area, the development of customer-specific software plays an important role as it can be specifically customised to the ICs which significantly increases the energy efficiency of the systems and the functionalities. Unfortunately, the good competitive position in this area has an Achilles heel: The development of embedded systems is highly dependent on the availability of semiconductor components which are fabricated in leading-edge technologies. There is a major risk in importing ICs from the producing countries because of export bans, economic or political

reasons. Europe, as a result, would be unable to produce any further systems and would significantly fall behind on the market.

These dependencies must be overcome!

What are the main questions?

Semiconductors do have a significant role in the value chain for the simple reason that most other information technologies are based on them and that they cannot exist without them. Often the innovation potential is based on semiconductors. We must therefore ask ourselves whether Europe can succeed in global competition without its own strong semiconductor industry and whether it could be a leader in the automotive manufacturing, automation technology, medical and environmental technologies sectors. If we agree that a strong European semiconductor industry is necessary, we have to ask ourselves what we need to obtain, strengthen and how to expand it. In our opinion, the specific main questions are:

1. How can we stop and reverse the trend of Europe falling behind in semiconductor production in a global comparison year by year?
2. How can Europe regain, maintain and expand its technological sovereignty in the field of electronic systems?
3. What funding programmes must Europe develop in the field of semiconductors? What can we learn from the USA and Asia, in particular from China?
4. What measures must Europe take to set up trusted technologies in the semiconductor industry?
5. How does Europe have to organise its economic promotion in order to regain core segments of the semiconductor industry?
6. What contribution is required from industry, universities and research institutions?

We need answers to these questions!

What should the politicians do?

1. Set up an “Electronics for Europe” master plan

The significance of semiconductor fabrication has certainly been recognised in the past few years and as a result, repeated efforts have been made to massively promote the European semiconductor industry. Thus, in 2014, under Neelie Kroes (the former Vice President of the European Commission), the very ambitious plan to double the production of semiconductor components within the next 10 years was installed. One of the most important actions was to create the IPCEI programme (Important Projects for Common European Interest) to promote semiconductor production in Europe. In 2018, the Electronic Leaders Group and the EU Commissioner Mariya Gabriel published the white paper Boosting Electronics Value Chains in Europe that presents a very clear vision for a strong semiconductor industry in Europe. What is still missing? Europe, by global standards, is still slipping year by year. The current actions and supporting measures are not enough because, in other places, in particular in the USA and China, the strategic importance of semiconductors has been recognised and long-term master plans to build an electronics industry have been promoted for years. Europe has the choice between continuing half-heartedly or significantly stepping up the pace and setting up its own master plan for a “European Semiconductor Fabrication”. The central aspect of such a master plan must be an industrial policy, agreed on the European level that ensures the production of semiconductor components in Europe. Germany must assume a leadership role in defining this industrial policy.

2. Establish Europe’s technological sovereignty

The question of Europe’s technological autonomy is fundamental. We must ask whether we would like to shape economic development or if we want to slip down into the role of the consumer and ultimately end up in the same category as developing countries. The objective of being technologically independent is to keep essential parts of the value chain within the European territory. Europe cannot rely on the purchase of essential semiconductor devices in the global supply and should therefore demand a certain share of added value in Europe for products based on semiconductor devices. Even if, for instance, there are no longer any companies in Europe that manufacture CPUs/GPUs, the European Union can demand from the manufactur-

ers located in overseas countries that a certain portion of the devices and ICs used in Europe must be manufactured in Europe. As a result, the major semiconductor manufacturers will also have to build semiconductor factories in Europe to be able to supply the European market. It is clear that the implementation of this economic condition is complex, as it requires political creativity, but there are also role models from other industrial segments, for instance, the automotive sector for locally demanded added value in other countries. The objective must be to have the knowledge (intellectual property) and the technology available in Europe and to counteract brain drains.

3. Allow greater risks in research

Significant funding is provided by the government for pre-competitive research and development, primarily for short and medium-term development projects. It is, however, necessary to promote research and innovation with a much longer-term horizon. The typical three-year projects supported by BMBF or the EU are not remotely adequate. In three years, evolutionary improvements can be achieved, but a horizon of at least 10 years is required for disruptive innovations. The goal of preventing market distortions is certainly honourable in a global market economy, but a global free market with the same rules of the game only exists in some areas of the field of microelectronics and the WTO cannot establish one. Especially in the field of data storage technology, there are comprehensive examples of this, for instance, the subsidisation of the Korean company Hynix over several years. Europe and Germany need to be more courageous and to act with more endurance when promoting new, disruptive technologies and new application concepts that, while of high risk, might ultimately result in new product developments.

4. Promote young talents and start-ups

Europe has relatively few raw materials, but it does have a versatile and very strong education system that produces many bright minds. This has to be further expanded and it is important to inspire those many young talents for technological developments and innovations in Europe. Europe must start initiatives with strategic support, provide a fruitful environment and protected space in which they can flourish before they can stand on their own two feet as start-ups.

5. Set up the promotion of the economy and supplement it with direct governmental contracts

In the USA, in the name of national security, the government awards subsidies and grants tax incentives to companies that want to build semiconductor factories in the USA. Germany can and should urgently learn from such successful economic promotions in the USA and Asia. Of course, the state must not become a contractor, which is not recommended here. It is about the fact that governmental action can be extremely useful for a market economy in the leading-edge technology sector. Even the success of Apple, one of the most successful companies in the world, traces back to a well-thought-out economic promotion programme in the 1980s. Teams consisting of municipal economic promotion programmes, companies and science are essential for successful start-ups. Germany needs to have the courage to push forward and expand the economic development and ultimately launch new, innovative companies in strategically important segments.

Market economy rhetoric in the USA and Asia must not hide the extent of the local constructive state influence on technological development. Especially in the USA, there are prominent success stories, for instance, the Internet was created as part of a DARPA initiative. The development of microelectronics, computer and software technologies was largely supported by government subsidies. Nanotechnology was initially developed by the National Science Foundation (NSF) and later through the National Nanotech Initiative.

In the 1980s, as part of a wide-scale development process, Taiwan founded TSMC, which is now the market leader for third-party production (foundry) of microprocessors and logic components with a turnover of more than US$ 30 billion. In China, the state plays a very active role with its industrialisation strategy by steering resources toward specific industrial sectors and securing participation in enterprises and research by cooperating with foreign partners.

The state not only has the ability to generate knowledge at university and research institutions, it should also assume a supporting and steering function with respect to the transfer of knowledge to the economy. It should certainly set strategic priorities and implement them both in long-term programmes and in direct governmental contracts in cooperation with partners from industry and research. Especially in the leading-edge technology sector, there are often very high risks, so that topics are not initiated by companies, but are in-

stead taken up once they have reached a certain level of maturity. Germany often holds a top place when it comes to the best ideas, but is unsuccessful in implementing them in innovative products.

Germany and Europe should focus particularly on their current strengths and massively support production of semiconductors domestically. At the same time, dangerous gaps in the field of advanced CMOS technologies have to be closed by demanding local value creation in Europe from semiconductor manufacturers outside of Europe.

Politicians shall recognise the importance of semiconductor technology and fabrication for Germany and Europe and set priorities accordingly!

Conclusion

The entire semiconductor value chain is currently highly dependent upon global developments because important components have to be imported from the USA or Asia and the major semiconductor companies have often relocated the production or large portions of the production of the chips and modules they develop to Asia. Today, the reason for the relocation to Asia is not as much the payroll costs as it is the general conditions there, which include a large number of very well-educated engineers and favourable financial conditions with respect to operations and investment costs, thanks to long-term industrial promotion policies in these countries. Nearly every major company, such as Apple, AMD or Nvidia, are currently reliant on contract-based manufacturers like TSMC in Taiwan. Especially because cutting-edge technology nodes are produced in the USA and Asia, political struggles and interests influence the global semiconductor market. There is currently a noticeable geopolitical power struggle between the USA and China that influences all supplier countries. Europe and Germany are also affected. The risk of ending up between the fronts is very real and the consequences would be huge because a ban on essential components might shut down a large portion of European industry.

Europe would be well-advised to more forcefully push forward the establishment of its own modern semiconductor manufactures. Reliable, safe and energy-efficient devices in particular should be manufactured in Europe on a significantly larger scale, especially in areas where they are used in greater quantities. It is high time for well-thought-out investment models, orchestrated by the governments, to significantly strengthen the future semiconductor sector in Europe from an economic and scientific perspective so that the European continent can become visible on the digitisation map again. Because of the global distribution of labour in the field of semiconductor production, there will always be a web of reciprocal dependencies; Europe must significantly improve its standing in this network in the interest of its economic and social security.

The good news is, that the battle is not lost. The train has not left the station yet, as is often claimed in discussions regarding European semiconductor manufacturing. Other countries have shown us how it might work: South Korea was a developing country in the 1950s and is now a leader in technology in many segments. Regardless of our current position, with the right priorities, the right focus and long-term programmes, the trend can be reversed. Well-meant words and undersized programmes set up for only a few years are not enough. Our urgent appeal is, therefore, to act now.

Further information

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