



Federal Ministry of Education and Research

Position Paper of the Federal Government on the future development of microelectronics in Germany

Summary

Microelectronics is a **key enabling technology** in modern industrial societies which is characterized by speedy development and a great impact on innovation in a large and steadily increasing number of user industries. **Germany** holds a **prominent position** in Europe due to the combination of the systems expertise of user sectors with the electronics industry's technological expertise. Sustainable mobility, energy supply, health, demographic change and industrial digitalization (Industry 4.0) combined with IT security are exemplary fields where high-tech expertise and the availability of technology for electronics systems enables intelligent solutions to be developed and fields of innovation to be exploited successfully. This expertise must be strengthened further by funding research, development and innovation.

Internationally, however, Germany faces major challenges together with other European Member States. Progress must be made in research and innovation in order to ensure access to all relevant basic technologies and a **better position** on the world market, visibly raise the share in global production and increase value creation in user industries.

With its European Strategy for Micro- and Nanoelectronic Components and Systems of May 2013, the **European Commission** presented a proposal and a **framework for future governance** of research and innovation funding at European level.

The German **Federal Government** will play an active role in developing and implementing the European funding strategy. It **supports** the proposal of the European Commission and will work to ensure greater and better coordinated investments in research, development and innovation in order to enhance the impact of R&D&I funding by EU Member States through stronger European cooperation.

This **Position Paper** of the Federal Government on the future development of microelectronics is the German contribution to the successful implementation of the European strategy. At the same time, the paper emphasizes national priorities, thus setting the **course for future national research funding**. The aim is to guarantee coherent funding of microelectronics at national and European level.

To achieve this we will

- Participate in **European initiatives** under Horizon 2020, particularly in funding programmes of the European public-private partnership ECSEL and other European initiatives.
- Focus our funding on accelerating the development of **intelligent and more reliable (micro)electronics systems** and **innovative power electronics**, strengthen the design of complex **chips and chip systems** to clearly enhance chip functions ('More than Moore' developments), and increase our leading edge in **chip-based security technologies**. Funding will increasingly focus on the innovation requirements of system users.
- Contribute to and support the development of **cutting-edge technologies** for the manufacture of state-of-the-art components.
- Consider the potential of **new technological approaches** and include them in funding as appropriate.
- Promote the further development of **production technologies** for electronic components and systems including equipment and material and for the **manufacture of semiconductors** mainly within European collaborations by funding European pilot production projects.
- Consolidate regional strengths and support **national networks of excellence**.
- Support **small and medium-sized companies**, thus enabling them to participate adequately in European programmes.
- Make efforts to ensure a sufficient **supply of skilled staff** and improve **general and local conditions** to encourage corporate investment in the microelectronics sector.
- Support European research alliances and selected international research collaborations.

The Federal Ministry of Education and Research plans to increase national funding for microelectronics and to double the German contribution to ECSEL.

1. Introduction

Microelectronics is a key enabling technology which is essential for the competitiveness of industrial products. It is developing quickly and has a major impact on innovation in a large and steadily increasing number of user industries. Developments in microelectronics have been characterized for decades by quickly increasing performance, growing cost-effectiveness and high investment cost for chip manufacture as a result of constant technological progress.

Microelectronics has a significant impact on the global economy. Leading industrial nations throughout the world have realized the importance of this key technology and placed it prominently in their research and industrial policies. The electronics sector in Europe employs 250,000 people itself and

more than 2.5 million people along the entire value chain and contributes at least 10% to European GDP.¹

In the last ten years, the German semiconductor industry has been characterized by a focus on technological strengths with great leverage on the user industries and fields of application such as automotive engineering, secure identification and transaction, energy electronics and sensor systems. In this way, major sectors were strengthened significantly in economic terms. The R&D expenditure of semiconductor companies accounts for more than 20% of total turnover and is thus among the highest in a cross-sector comparison. In view of the enormous pressure for innovation and investment, a European Strategy which aims to consolidate and systematically develop the technological expertise in microelectronics as well as domestic value creation in suitable sectors is of special importance. Unrestricted access to state-of-the-art developments in electronics is essential in global competition in order to enable German industry to be successful and continue to play a leading role with innovative products on global markets.

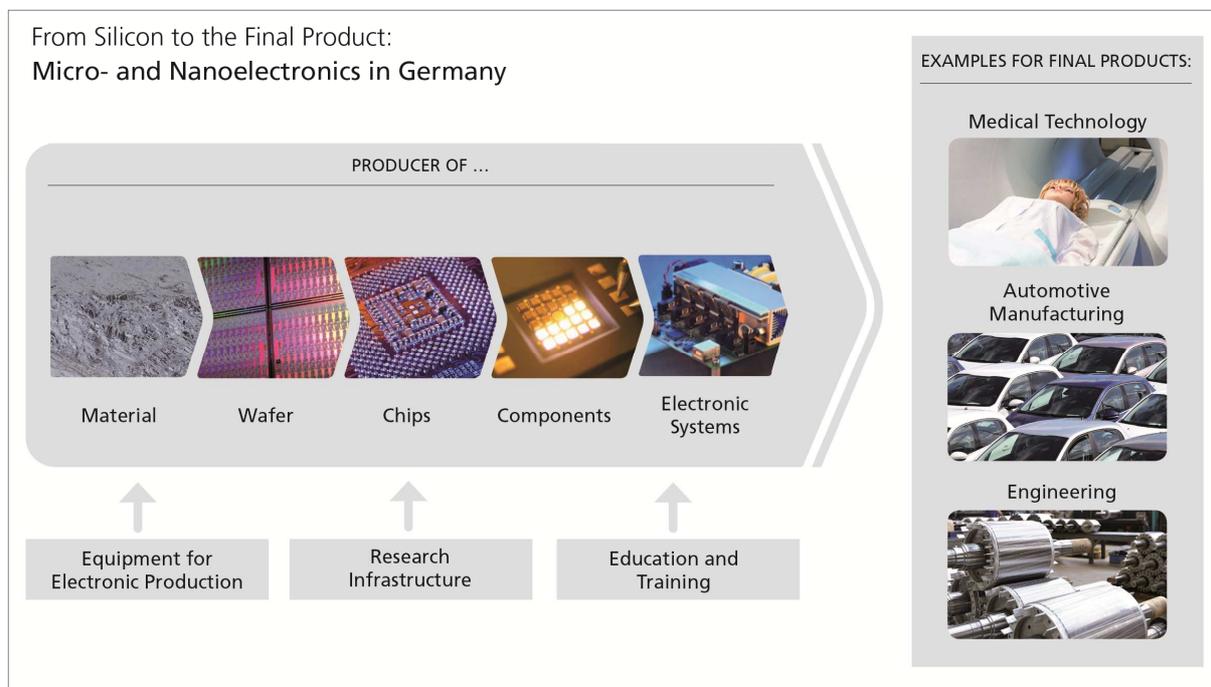
2. Electronics industry and electronics research in Germany today

A special strength of German industry is its great innovative power and the proximity of chip and technology development on the one hand and application on the other hand, which generates unmatched expertise in the use of microelectronics in innovative systems solutions. Small and medium-sized electronics companies provide excellent solutions for specific applications. Over the past 20 years, semiconductor firms in Germany have been increasingly abandoning traditional standardized mass products. There is a growing trend towards electronic chips being manufactured flexibly and individually by foundries for a broad range of customers. Germany also has relevant foundries which produce state-of-the-art semiconductor components according to customer requirements. Furthermore, leading manufacturers of discrete semiconductors and highly specialized security chips mainly for near-field communication are located in Germany. German manufacturers of security solutions for identification (e.g. authentication documents), secure transactions (e.g. payment) and networked car solutions are global leaders. Companies in Germany mainly focus on the development of application-specific components and systems. There is a stable and globally competitive industrial basis in Germany particularly for 'More than Moore' (MtM) technologies, which enable numerous applications of electronic systems by integrating analogue components. The integrated components and systems include sensors and actuators, high frequency and communication elements, power supply, micro electro mechanical systems (MEMS), optoelectronics and others. The 'System in Package' (SIP) technology line is well established in Germany. Different techniques are used to integrate various elements and components within an application-specific

¹ Electronic Leaders Group, A European Industrial Strategic Roadmap for Micro- and Nanoelectronic Components and Systems, 30 January 2014

package. System integration and packaging are major technical challenges and at the same time reflect the enormous flexibility and innovation potential of MtM.

Germany has special traditional strengths in the field of sensors and sensor systems and in system development as a whole. This is also due to intensive government support in recent years and a strong industrial basis. Leading industrial sectors and R&D expertise have developed and become successful on the market with highly innovative products and services based on innovative electronics systems. This applies to both suppliers (materials, components and systems) and traditional German user industries such as automotive and automation engineering, industrial electronics, production engineering, measuring technology, energy supply and medical and communications technology. These user industries are the mainstay of the German economy and special technology drivers. For example, four German companies are among the top ten international manufacturers and suppliers of electronic components and systems for the automobile sector. Two German companies are world leaders in power electronics; one German company is a leading manufacturer of optical systems for chip production. A large number of small and medium-sized suppliers are involved in these markets, and their developments contribute substantially to innovation. Companies in Germany have always played a strategic role in the global development of electronics manufacturing technologies including materials, lithography systems and mask technology.



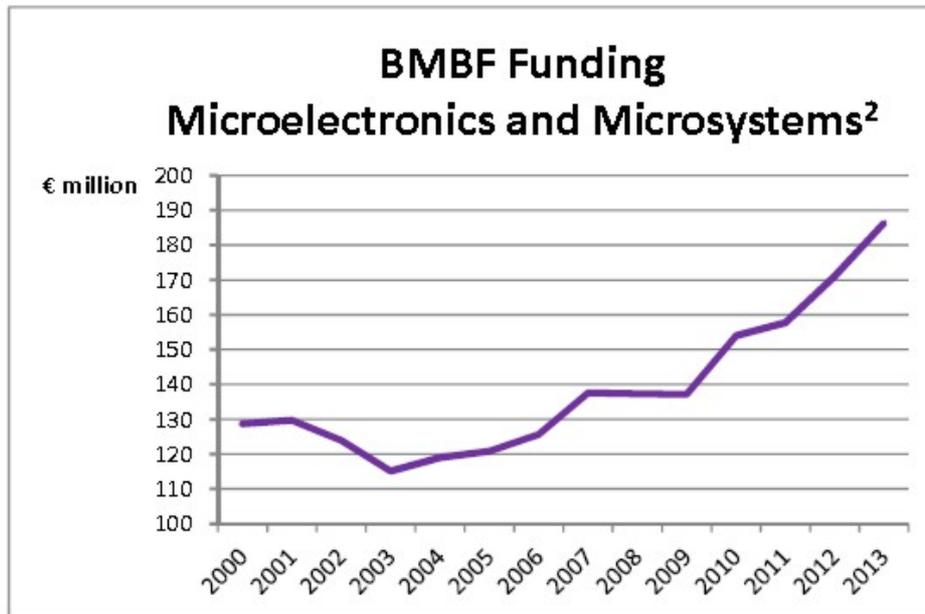
The electronics industry in Germany focuses on excellence both in high-volume markets (e.g. MEMS for the automotive and consumer electronics sectors) and in medium-volume and niche markets rather than on standardized mass products. A complete value chain in electronics combined with system expertise in user industries provides Germany with a unique basis for innovation in almost all areas. A competitive 'More than Moore' semiconductor and electronics sector including 'More Moore' state-of-the-art components such as microprocessors and ASICS therefore remains essential and vital for German industry in future.

A particular strength of research in Germany is the broad range of basic and application-oriented capacities and infrastructures. Micro and nanoelectronics is an integral part of the research programmes of the large research organizations in Germany: Fraunhofer, Max Planck Society, Helmholtz Association and Leibniz Association. The Fraunhofer Group for Microelectronics was established in 1996; it comprises 12 Fraunhofer institutes and employs approx. 3,000 people. Numerous activities in basic and applied research are carried out at universities and universities of applied sciences. Electronics expertise is available in almost all of the German *Länder*. Regional clusters bring together innovation activities along the value chain. Furthermore, German research institutions are involved in relevant international research alliances. Microelectronics training and advanced training are also firmly established.

Due to their completeness and quality, these innovation factors place Germany in an excellent competitive position on a global scale. This position must be further enhanced in order to maintain the country's technological power and potential for economic development and the solution of future social challenges.

3. Funding by the BMBF

Research and development (R&D) in the areas of micro and nanoelectronics, microperipherals and microsystems as well as their applications have been funded continuously since the mid 1990s. Between 2000 and 2013, the BMBF provided approx. €40 million p.a., totalling almost € billion and reflecting an upward trend.



Under the Federal Government's High-Tech Strategy and the BMBF's ICT 2020 research programme, funding for technology development focused on solutions and applications to address social challenges in the areas of energy, health, mobility, security and communication. The increase in funding from 2009 is due to support for electric mobility and leading-edge clusters (*Spitzencluster*). The system concept plays a major role in this context. The priorities of funding are increased functionality of electronics systems and system integration. Funding is furthermore provided for alternative basic technologies for future micro and nanoelectronics, for example one-dimensional electronics and organic electronics.

BMBF funding for leading-edge clusters like 'Cool Silicon' in Saxony and 'MicroTec Südwest' in Baden-Württemberg promotes regional networking between research and industry. Semiconductor manufacturers, materials and technology suppliers, research and service institutions as well as system manufacturers have established excellent R&D infrastructures through cooperation in projects.

Specific measures focus on the recruitment and training of new staff. The aim is to raise young people's interest in electronics and encourage students to engage in research. In this context, the BMBF supports the 'Invent a Chip', 'Drive-E' and 'SolarMobil Deutschland' competitions for school students and the COSIMA microsystems competition for university students.

² Incl. microelectronics funding from the Energy and Climate Fund

4. National priorities under a European microelectronics strategy

Germany holds a prominent position in Europe as it combines the systems expertise of strong user sectors with the electronics industry's technological expertise and can rely on a broad-based and efficient research sector. Internationally, however, Germany faces major challenges together with other European Member States. Progress must be made to secure a better position in the world market, visibly raise the share in global production and increase value creation in user industries. Research for new technologies and products can make an important contribution in this respect.

The European research and innovation funding programme 'Horizon 2020' started in 2014. It will strengthen key enabling technologies to support the global positioning efforts of European economies in the period up to 2020. The three key priorities of the programme are excellent science, industrial leadership and societal challenges. The European Commission also published the European Strategy for Micro- and Nanoelectronic Components and Systems³ in May 2013. Core objectives of the strategy are to double the European share in the world market for semiconductors, to focus on European strengths and Europe's leading clusters of excellence, to seize opportunities arising in non-conventional fields, and to support the growth of small and medium-sized enterprises (SMEs). The strategy highlights three important lines of development for microelectronics: more intelligent chips ('More than Moore' technologies, that is, greater functional density and diversity with a focus on systems and applications), quicker and more energy-efficient chips ('More Moore' technologies, that is, enhanced integration density and smaller chip structures) and cost-effective technologies for chip production (shifting to 450 mm wafers).

The European semiconductor industry positioned itself in late 2012 with a strategy paper entitled "Innovation for the Future of Europe: Nanoelectronics beyond 2020"⁴. The paper proposes among others a holistic approach to the further development of the nanoelectronics network. The envisaged priorities include increasing cooperation between industry and research institutions, establishing pilot lines, the extension of microchip manufacturing in Europe on 300 mm wafers, accelerated materials and infrastructure development for 450 mm wafer manufacturing, and a greater focus on chip, system and applications development. The paper sees a need for public and private co-investment to implement the programme and ensure Europe's competitiveness in view of the comprehensive public support provided for R&D outside Europe.

The Federal Government will play an active role in the fine-tuning and implementation of European funding strategies. It supports the European Commission's proposal and will work to ensure greater and better coordinated investments in research, development and innovation. At the same time, the Federal Government will increase national efforts in the field of research and innovation in order to enhance the impact of R&D funding by EU Member States through stronger European cooperation.

European programmes and strategies form a framework which is to be filled with measures of the Member States. The Federal Government pursues the goal of strengthening the domestic

³ COM(2013) 298 final

⁴ AENEAS/CATRENE Office, 2012

microelectronics sector in order to open up new markets with innovative and sustainable products and markedly raise value creation in Germany and Europe by 2020. This Position Paper on the future development of microelectronics is the Federal Government's contribution to successful implementation of the European strategy. The BMBF will focus research funding in the field of microelectronics on the priorities identified below and will participate in European initiatives under Horizon 2020, particularly in funding programmes of the ECSEL Joint Undertaking and other European initiatives.

4.1 Develop strengths

Funding will focus on the development of intelligent and safe electronics systems and microsystems, the further development of innovative power electronics, and chip and systems design for complex systems. Technology development will therefore be matched systematically with the innovation requirements of system users.

Support intelligent, reliable (micro-)electronics systems

German semiconductor and system manufacturers are international leaders in the area of 'More than Moore' technologies as regards both research and development and the manufacture of electronic components and systems. Germany's strength in 'More than Moore' development and production is based on close links with the value chain of related industries. An important element in international competition is to provide for sophisticated products which are unaffected by the risks associated with non-European semiconductor suppliers. Specialized hardware technologies are needed to develop a broad range of functions and increase the reliability of electronics systems.

As the traditional microelectronics sector requires peripheral components like sensors and actuators, microsystems technology has become an established field and developed towards smart system integration in Europe, and in Germany in particular. Funding is provided for new developments leading to more intelligent, more integrated, compact and reliable (micro-)electronics systems which offer sensor, signal processing and communication functions and can be linked in networks. New sensors, integration techniques and new materials are of special importance in addition to software.

Promote innovative power electronics

Power electronics is vital to ensure the efficient conversion of electrical energy into other forms of energy required for individual applications and provide for energy efficiency in power flow control. It is a generic technology which plays a key role in various applications in fields such as electric mobility, industrial production, home appliances and building services, plant and mechanical engineering, and automation. Germany is a leading manufacturer of power electronic components and systems. Support is provided for efforts to further increase the systems' intelligence and energy efficiency at competitive cost and for new technological developments, for example on a silicon carbide or gallium nitride basis. The great electric strength and current density which can be achieved in this way enable world-class smart power solutions for strategic applications in such areas as industrial automation, renewable energy and electric mobility.

Strengthen chip and system design for complex systems

The design process starts when a technology becomes available for application in a product. The increasing miniaturization of semiconductor technology and the great functional diversity and density of complex systems offer potential which can only be tapped if design keeps pace to ensure that new chips and systems can be brought to production at an early stage, error-free and at competitive cost. Today, complex chips are developed using computer-based tools. Design has thus become another area of key expertise beside manufacture. This applies to both 'More Moore' and 'More than Moore' technologies. Design will increasingly take place at system level in future. A special focus in this context is linking functional design with relevant technologies for manufacturing the overall system while meeting reliability requirements (chip/package/system co-design). Funding is therefore provided for the development of new design methods and tools in order to secure a competitive value chain, also with a view to chip production in a German or European foundry. Facilitating system development cooperation along the value chain – from manufacturers of miniaturized components to users – is an urgent challenge which needs to be addressed in order to accelerate innovation while ensuring maximum reliability and precision. A higher rate of innovation is becoming increasingly linked to the market success of electronic systems.

Increase our leading edge in chip-based security technologies

Networking will increase to an estimated 50 billion nodes or more by 2020. Ensuring data security and integrity is therefore a major challenge. This includes not only data which can already be exchanged via media such as mobile phones or the internet but also data which require real-time generation, communication and processing. Secure networking between machines, workpieces and logistics systems and the availability of secure digital identities of people, machines and servers is a key innovation factor for leading German manufacturers in areas such as mobility, industrial automation, production technology and medical technology. Funding is provided for research and development in order to increase our leading edge in chip-based security technologies.

4.2 Consolidate and develop expertise systematically

A further aim is to secure access to new and other important technology developments and to extend existing expertise – for example in the area of production technologies.

Contribute to the development of highly integrated systems and new technologies in electronics

It will become very important in the medium and longer term to be actively involved in new 'More Moore' developments and use the synergy produced by 'More than Moore' developments. R&D measures are supported for the further development of new assembly and joining techniques, the advancement of ultra low power technologies and the development of new technologies for new product groups (e.g. 1D electronics, organic and printed electronics, graphene, nanoelectronics, convergence of 'More Moore' and 'More than Moore').

Promote progress in production technologies and production

World-class manufacturers of material and equipment for chip production have become established in Europe and Germany. Manufacturing technologies for semiconductor production are therefore of great importance for Germany and Europe, particularly when they provide European manufacturers with access to state-of-the-art production technologies. With a view to solving the challenges of coming years, funding is provided not only for the advancement of individual technologies such as EUV lithography and technology and equipment for 450 mm wafer production but also for advancing existing production technologies and optimizing them for 300 mm wafers, for example for application in the area of wafer level 3D integration. Funding also focuses on developments in the areas of innovative materials and plant technology. A holistic approach including process, materials and plant/equipment is required to develop new modern technologies. Relevant projects will mainly be implemented as European collaborations.

Production technology for assembly must be further enhanced in order to ensure an uninterrupted value chain from semiconductors to final products. This includes, for example, new equipment and processes for high-precision, reliable and low-cost assembly of small and varied components to produce complex electronic and multifunctional modules and systems.

A significant increase in value creation in Germany and Europe is a major goal of microelectronics funding programmes. It is therefore important to consolidate and develop the entire value chain including electronics systems. An increase in chip production is expected to go hand in hand with a growing share in markets for innovative products. The construction of pilot production lines, also for electronic components on 450 mm wafers, is supported under European collaborations provided that the participating companies commit themselves to investing in the construction and expansion of production lines in Europe.

Strengthen networks of excellence and SMEs

The complexity of microelectronics in research, development and production requires the pooling of different expertise from numerous scientific and engineering disciplines in networks of excellence and

regional clusters. The aim of BMBF funding is to promote regional strengths and to support the national competence centres and networks of excellence in Dresden/Chemnitz and in the Nuremberg/Erlangen metropolitan area as well as in Dortmund, Erfurt, Freiburg, Hanover, Munich and Stuttgart. We therefore welcome the Fraunhofer initiative to establish national centres of excellence in the areas of microelectronics and electronics systems and the envisaged intensification of cooperation with European research organizations like CEA-Leti in France, IMEC in Belgium and TNO in the Netherlands.

Small and medium-sized enterprises are strongly involved in the design and manufacture of intelligent electronics systems. SMEs have special systems expertise and are therefore an important driver of innovation and a major interface for the transfer of research results from science to industry. Support is provided for SMEs in order to enable them to participate adequately in national and European programmes (*KMU-innovativ* ICT, *KMU-innovativ* Production Research, SME Central Innovation Programme (ZIM), Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME)).

4.3 Improve general and local conditions

Microelectronics as a high-tech sector can only be successful with creative, committed and well-trained people. The Federal Government supports recruitment and training measures to ensure a sufficient supply of skilled workers, thus addressing the problem of an impending skills shortage.

We want to make Germany an attractive industrial location for electronics systems and chip production technologies. In particular, general conditions will be improved to enhance relevant electronics expertise in industry and science so that Germany can become a leading player in the design of future innovations of the digital economy and society. This includes securing a level playing field for all market participants. However, governments in Asia, the USA and Europe provide disparate levels of assistance for microelectronics companies, which lead to a bias in local conditions. The Federal Government therefore supports the EU's efforts to stop or limit the current subsidy race between the European, North American and Asian economies. Furthermore, the Federal Government aims to encourage greater corporate investment in the microelectronics sector. Consideration will also be given to the options provided by the new EU state aid legislation.