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Hidden Electronics III

Call for Action on Electronics from Europe

What a potential EU Chips Act would have to consider

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Motivation

With its innovative, broad-based and export-oriented industry, Germany holds the pole position in the European industrial landscape. Highly innovative microelectronics technologies have always been an essential element of this landscape. In December 2020, a group of VDE members launched the position paper “Hidden Electronics II”. This position paper and the statements made therein were also shared by EUREL in a position paper of the same name. Hidden Electronics II intended to emphasize that microelectronics has got a fundamental importance for our economy and for our society.

Without innovations in all areas of microelectronics, it will be impossible to solve the future challenges of our society in areas such as climate change, climate-neutral mobility, digitalization, and sustainable energy supply. With well over 50 percent of Europe’s micro-electronics production, Germany plays a prominent role and must face up to its responsibilities in this field. To ensure that Europe has fair, nondiscriminatory and crisis-proof access to global microelectronics solutions, it needs a powerful, innovative microelectronics ecosystem as well as technological sovereignty in key areas of the value chain, from materials to equipment all the way up to design and high-volume manufacturing.

Since 2020, the economic and political situation has changed significantly: a global chip shortage is paralyzing not only the automotive industry but also many other areas that use microelectronic components; Intel wants to decide this year whether to build a new “mega-fab” in Europe; and TSMC is holding serious discussions about major investments in Europe. In the US, 50 billion dollars in funding for the microelectronics industry have been announced for the next few years. Similar mid-double-digit billion sums are being provided in South Korea (“K-Semiconductor Belt”). China has stated that it aims to manufacture 70 percent of its own semiconductors by 2025 – microelectronics is a key component of the “Made in China 2025” initiative. The struggle for supremacy between China and the rest of the world is sharpening.

The EU also wants to catch up in microelectronics. However, the measures taken in recent years have not been sufficient to achieve this goal; they have at best been able to slow down the negative trend in sales, production capacity and investment, but by no means to reverse it. Instead of the targeted 20 percent share of global sales, the figure is now only 7 percent. Bosch’s wafer fab in Dresden is the only new production site to have opened in Germany in the past two decades. In contrast to this, entire production sites, including Böblingen, Alsdorf, Munich-Perlach, Landshut and Heilbronn, have been closed and other production sites are becoming obsolete, requiring substantial renewal investment.

The importance of microelectronics for the European economy has been well recognized in politics and as a result, a series of programs were launched both at national and at European level in order to again strengthen the own position. These programs were the right and necessary ones and have succeeded in maintaining Europe’s strengths, for example in power electronics or sensor technology. However, gaining background for European´s microelectronics and maintaining a strong presence long term requires a tremendous effort. The FMD (Forschungsfabrik Mikroelektronik Deutschland - Research Fab Microelectronics Germany) or the initiated four 6G HUBs in Germany are good examples of recent and current funding measures helping reverse the past years’ trend. But there is an urgent need to further advance these funding measures in terms of scope, duration, sustainability, and overall

strategy. In contrast, the USA and the relevant Asian countries have expanded their funding measures within the framework of large-scale master plans and with a multiple of the funds which were made available in Europe. The whole has proved to be very promising. In doing so, economic aspects are considered at all levels, but also the targeted state promotion of top research and development at universities and other research institutes. In the meantime, the European Commission has announced its ambitious European Chips Act plan which is welcomed as an important step in the right direction.

Without comparable concepts and a strong positioning of the EU as a serious competitor in the international arena, the competitiveness of the EU in the field of microelectronics will continue to erode. This would not only have enormous consequences for the economy and the research landscape but would have a lasting negative impact on society in Europe. Once the basic knowledge, the research resources and ultimately the ability to develop state-of-the-art semiconductor components and manufacture them in Europe are lost, Europe will lose its influence on the entire industrial development. The result of this very fast-moving development, which we are currently observing with concern, is a complete dependence not only on non-European companies, but also on non-European political powers.

In the competition for the future of microelectronics as a central enabling technology for our economy and society, Europe can succeed if it now acted swiftly, efficiently, and strategically in the form of an elaborated master plan. With this paper, the authors would like to send a wake-up call to the decision-makers in politics, society, and the economy.

Starting Point

The present position of Europe and the future trends in microelectronics and associated industrial companies are well known and are no longer the subject of this appeal. However, we need to have a realistic look at the effectiveness of previous funding policies and analyze their shortcomings:

- Why has the European position in the global semiconductor business not improved, but rather deteriorated, despite the renewed funding efforts over the past years?
- Why was more funding not made available?
- Why are we incapable of adapting our highly complex decision-making processes and policies as EU state aid law to the global realities and recognized necessities of the 21st century?
- Do the European funding systems meet the requirements in terms of flexibility, conditions, and speed to be competitive in an international and highly dynamic environment?

The questions above need to be answered differently for different technology areas.

In the field of advanced CMOS logic, a consolidation and concentration has taken place in recent decades, with only three major manufacturers surviving, i.e., Intel, Samsung and TSMC. During the same period, Europe lost large parts of its ICT and consumer electronics industry with the result that European demand for advanced CMOS logic devices has shrunk. The situation does not necessarily have to stay like this forever – the demand for advanced CMOS logic devices will increase massively in the next few years, especially in the automotive sector. Demand will be driven further by the trend toward performing computing not only in the cloud,

but on edge devices, affecting virtually all electronic sectors. Due to these market-strategic and geopolitical considerations, both Intel and TSMC show an interest in building new advanced CMOS fabs in Europe. Europe should do everything possible to seize this opportunity and support the establishment of such fabs. Investments in advanced CMOS semiconductor manufacturing are very long-term and accompanied by related research activities on process and equipment development, material science etc. – will play a crucial role in Europe's technological sovereignty in the coming decades. Establishing these fabs would offer a unique opportunity to rebuild semiconductor manufacturing operations and know-how at the latest technology nodes in Europe. If these two companies set up wafer fabs in Europe, this would substantially strengthen European expertise and the microelectronic ecosystem. Even if the chips from the smallest nodes were initially used for production of electronics mainly in Asia, the positive impact on the European market would become essential after some time.

In the field of what is known as More-than-Moore technologies – including sensors, power electronics, optoelectronics, analog chips and others – Europe maintains a strong position. These technologies are based on larger technology nodes but can be classified as absolutely equivalent to advanced CMOS technologies in terms of their level of innovation. In many cases, the well-chosen mix of technologies, design and packaging to the application is the key to success.

The Application Pull of the automotive and industrial user industries has played a very positive role in the development of More-than-Moore technologies in Europe and demonstrates the importance of interaction along the value chain from semiconductor manufacturing to end product. Infineon Technologies and Bosch have made significant investments in these technologies in Europe (Bosch: 300mm fab in Dresden; Infineon: investments in Dresden and Villach) to keep the know-how in Europe. The importance of Morethan-Moore technologies has been recognized in Asia and the US and strong governmental efforts are being made to develop these technologies there as well. While decisions to invest in manufacturing are complex they are supported strongly by public funds in Asia but also in America.

In Europe, there are many hurdles that, taken together, play a negative role in investment decisions, such as:

- A complex tax system that is not very appropriate for large-scale investments (among other things, because of the limited depreciation options)
- Limited funding possibilities for investments in manufacturing
- Lots of bureaucracy, many regulations
- High costs for electricity and water
- Restrictive competition and antitrust policies limiting cooperation between companies, or at least much stricter interpretations than in Asia or the US.

This list shows the difficulties that will be need to be tackled, when making location decisions in Europe, both for the modernization of existing production sites and even more so for new establishments.

Unfortunately, the construction of the Bosch factory in Dresden has been the rare exception within the last 20 years, whereas many new factories were built in Asia during the same period. The risk for new investments is also comparatively high in view of lengthy approval procedures and complex decision-making processes, for example in energy or financial policy.

In addition, there is a growing shortage of skilled workforce and a diminishing ecosystem for microelectronics in terms of scope and quality.

Need for Action

The authors propose the elaboration of a concerted, long-term European master plan for the semiconductor technology with the following key areas of action:

1) Regularly **review the effectiveness and efficiency of funding systems** for microelectronics:

a) Analyze microelectronics strategies in the US and relevant Asian countries.

b) Benchmark and validate European and national funding measures in Europe with regard to effectiveness of formats, durations, use of funds, application and selection procedures, reporting, performance reviews.

c) Coordinate and pool funding measures at the regional, national, and European level.

d) Conduct regular reviews and optimizations in state aid law and the funding system for microelectronics based on it.

2) **Increase the attractiveness for the establishment of new sites:**

a) Reduce of the existing competitive disadvantages for European companies concerning establishment and operating costs, competition law and taxation.

b) Expand funding opportunities for the semiconductor industry on its way to competitive volume productions as a counterweight to geopolitically motivated subsidies for the Asian and US semiconductor industries.

3) **Strengthen companies and fund start-ups in the field of microelectronics** and its applications (including consumer electronics, information and communication technology, Internet of Things, big data, health):

a) Improve the conditions for establishing and developing start-ups in future-oriented fields.

b) Build strong cluster structures to host networked centres of excellence that support and attract companies.

c) Create or enable economically favourable access to microelectronics and components (e.g., package solutions) for small and medium-sized enterprises on a small to medium scale.

4) **Promote university and non-university research**:

a) Revitalize and strengthen the microelectronics ecosystem by ensuring technology and design tool access for universities and SMEs.

b) Provide sustained, long-term support for major publicly funded capital projects to keep the facility and equipment park up to date.

c) Adapt decision-making and implementation mechanisms to the time frames required in the dynamic field of microelectronics regarding investments and funding of university and non-university research.

5) **Promote young talents** in schools, vocational training, technical training, dual training, technical colleges, and universities by reinforcing training in the field of microelectronics with a view to the entire value chain (IC design, AI, process technology, manufacturing automation, etc.) for current and future requirements, and create a suitable framework and incentives to attract talents and skilled workers from other regions to Europe.

6) **Conduct information campaigns on the importance of microelectronics for the society** at large, for example in the areas of climate change, energy supply, mobility, and security. Many sectors of the population are unaware of the pivotal importance of microelectronics as an enabling technology for the economy and society, and thus as a guarantor of technological sovereignty, partly because microelectronic components are not visible to ordinary citizens, but “hidden”.

List of important topics for the master plan

The revitalization of microelectronics in Europe and the associated improvement of technological sovereignty must address the entire spectrum of microelectronics. It is important not to neglect today’s strengths, but it is equally important to rebuild areas where Europe has fallen behind. The master plan must aim to maintain and expand European semiconductor manufacturing capacities as a goal, and it must address important technological research and development topics. The scale of financing must be in the double-digit billions, in line with the Asian and US master plans, if less then will not bring us to our goal.

In the following, the authors present for discussion what is certainly not an exhaustive list of technological topics, selected along the four functional lines of microelectronic systems “Sense, Think, Act, Connect”, including cross-domain topics that should be considered in the establishment of the master plan.

Sense (sensors/MEMS/…)

- Boost expertise in the field of MEMS technologies and components:

  - Strengthen design methodologies for leading edge MEMS components and micro/nano-optical sensors and systems.

  - Expand simulation, test and verification methods for the development and qualification of MEMS and micro/nano-optical components and systems.

  - Further develop expertise for new fields of application with the highest demands on precision and reliability.

  - Expand highly automated manufacturing capabilities for MEMS components and scale associated technologies for future substrate sizes.

- Strengthen and build up expertise and manufacturing capabilities in 3D system integration for advanced packaging technologies (SiP, SoC) and heterogeneous integration.

- Intensify research and development in the field of electronic-photonic integration and in the area of silicon photonics for sensor technology and communication.
- Boost expertise in new materials to develop new sensor principles such as for the smart nose.
- Intensify research and development in the field of SoC design, especially for environmental sensor technology (radar, lidar, video) for industrial automation and for automotive applications, including autonomous driving.
- Open up and integrate new sensor functionalities in the biomedical field for current applications, for example in the analysis of environmental data and vital signs.
- Expand expertise in the area of sensor-related signal processing including AI and sensor fusion, embedded in the sensor hardware for energy-efficient data transmission ("from raw data at the edge"). This includes setting up edge data processing.

Think (processing/AI/SoCs/...)

- Boost the fabless ecosystem in Europe in particular by amplifying academic education in areas such as advanced CMOS logic SoC design, embedded AI and advanced CMOS technology processes.
- Strengthen design and manufacturing capabilities for semiconductor technologies that are particularly important for Europe (mixed signal, low-power and high-frequency SOI, high voltage, etc.).
- Build up and strengthen European leadership in vehicle computing and edge computing, establish an open-source hardware ecosystem based on modern instruction set architectures such as RISC V as an alternative to proprietary computing cores.
- Ensure easy access to state-of-the-art development tools and IP also from the academic world and attractively priced licenses of these tools for start-ups.
- Consider new memory technologies in the design tools, i.e., make more flexible use of these tools to integrate new information processing procedures at the circuit level.

Act (power semiconductors/electronics

- Expand expertise in the field of robust, durable and energy-efficient technologies for power electronics components (SiC, GaN, etc.).
- Promote the expansion of manufacturing capacity for advanced power semiconductors and modules.
- Strengthen research and development on new materials and concepts for power electronics devices.
- Establish and expand expertise and manufacturing capabilities for advanced packaging technologies, 3D integration, heterogeneous integration with a focus on power electronics applications.
- Strengthen the development and design of intelligent power modules for efficient power management.

Connect (wired und wireless connectivity)

- Define 5G/6G system requirements for semiconductor components and participate in 5G/6G standardization.
- Set up of demo systems for campus networks and vehicle-to-X communications; establish a leading position in 5G/6G applications for industry and mobility.
- Develop IT-secure components for 5G/6G systems.
- Develop and expand expertise in the field of THz and silicon photonics technologies.
- Strengthen design capabilities in the area of sub-5nm technologies and encourage the development of ultra-low power technologies such as

Next Gen-FDSOI and eNVM

- Improve information security from hardware to software development as an overall concept, set up holistic certification standards with the “Made in Europe” seal of quality.
- Strengthen research on new approaches for energy-efficient information processing in the face of steadily increasing data transmission rates.

Cross-domain topics

- Develop design tools for electronic circuitry and systems, ensuring that these tools remain in Europe.
- Strengthen design methodologies in the area of high-precision analog and mixed-signal ASIC circuits and in the area of model-based systems engineering.
- Design complex systems and circuits, including the fabless design environment, system-on-chip integration, and open-source hardware.
- Use heterogeneous integration as the basis for refining components and subsystems, for example with chiplet technologies.
- Ensure technological sovereignty for mission-critical subsystems (for example, trusted electronics, split manufacturing including supply chains).
- Expand special, profile-creating niche technologies such as NVM edge AI applications.

These recommendations for action are not exhaustive. Rather, they are intended to serve as a collection of topics for developing the master plan. In summary, scalability and system integration represent the central technical challenges for the further development of microelectronics. They are likely to raise a whole series of further research and development topics that cannot be defined more precisely today. It is important to establish the master plan as a long-term plan with a horizon of at least ten years. Short-term goals need to be defined in more detail today, but they will have no effect if the long-term vision has not been clearly articulated.

Conclusion

Europe would be well advised to push ahead with the establishment of their own modern microelectronics manufacturing facilities and with the development of the associated ecosystem at all levels. Otherwise, the design capability for electronic components and systems in leading edge technologies will also be lost, going hand in hand with the loss of innovation leadership in key European industries.

Taking the existing programs as a basis, it is now high time to intensify the development of a well-considered, a coherent and comprehensive strategy at European level to get microelectronics “Made in Europe” back on eye level with non-European players. Given the global division of labor in the field of microelectronics manufacturing, there will always be a web of mutual dependencies.

In the interest of its economic and social security, Europe must substantially and rapidly improve its standing in the global microelectronics network and become visible again on the map of digitalization. The development of an “Electronics from Europe” master plan – in a concerted action of the EU, EU members, the semiconductor industry and especially the user industry as well as non-university and university research – is an indispensable step toward achieving this goal.