

## Development of Microelectronics in the Circumstances of the Innovative and Technological Growth of the Russian Economy

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**Abstract:** Currently, all major countries, both developed and developing, tend to support microelectronics, seeing it as a key driver of innovation and the socio-economic progress. Many governments support initiatives in the field of microelectronics if they are aimed at solving problems in the country. This study considers the current state of the Russian microelectronics, analyzes the problems of this industry from the stage of production to the sales stage and studies the nature of these problems. Particular attention is paid to the government's role in regulating and supporting the given industry and the domestic microelectronics market is compared with the world's ones. Given the fact that the microelectronics industry is a very sensitive sector which is closely related to the interests and security of the state, the study sets out the basic provisions for further revolutionary development of microelectronics.

**Key words:** Microelectronics, microelectronic products, technological backwardness, innovation, problems microelectronics, miniaturization of electronic components, the creation of internal and external markets, state order, public financing, microelectronic clusters, state program of the Russian electronic industry

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### INTRODUCTION

Russian microelectronics is probably one of the most controversial issues of domestic electronics. An own microelectronics industry is a must for a strong country. And because its development requires considerable expenditures, it is impossible to avoid government investment. This relates not only to financing enterprises that produce components. A healthy economic environment is needed as well. If Russia is going to have its microelectronic businesses, it should take steps to make the production of components economically beneficial (Perez, 2009).

Despite the significance of this industry, the current situation can be called a "powerful technology lag" which is characterized by the following indicators. Compare: Intel processors are mass-produced using the 32 nm technology, the leading semiconductor companies are implementing the 20 nm technology and in Russia, installation of a line using the 90 nm technology is considered a breakthrough. The current productivity in the Russian industry is about 8 times

lower than in the US and Germany. The domestic microelectronics market is <1% of the world market.

**Relevance of the problem:** The microelectronic and related industries form the basis of the modern technological waves. Therefore, their priority development in the world's leading economies is seen as the most effective way to improve global competitiveness and the basic factor in ensuring the state's power. Products of microelectronics are used by both individuals (driver's licenses, SIM-cards) and the government (anti-aircraft missile systems providing the country's security) (Fig. 1). Furthermore, the semiconductor industry itself is a driver of other industries and the country's economy as a whole.

**Problem study:** When Deng Xiaoping, a Chinese politician and reformer, began his reforms, he decided to ask the leading Japanese businessmen the question: "What kind of industry should be developed in China in the first place?" And they answered, "Electronics because if you have electronics, you will be able to do anything". Electronics permeates all equipment from refrigerators to

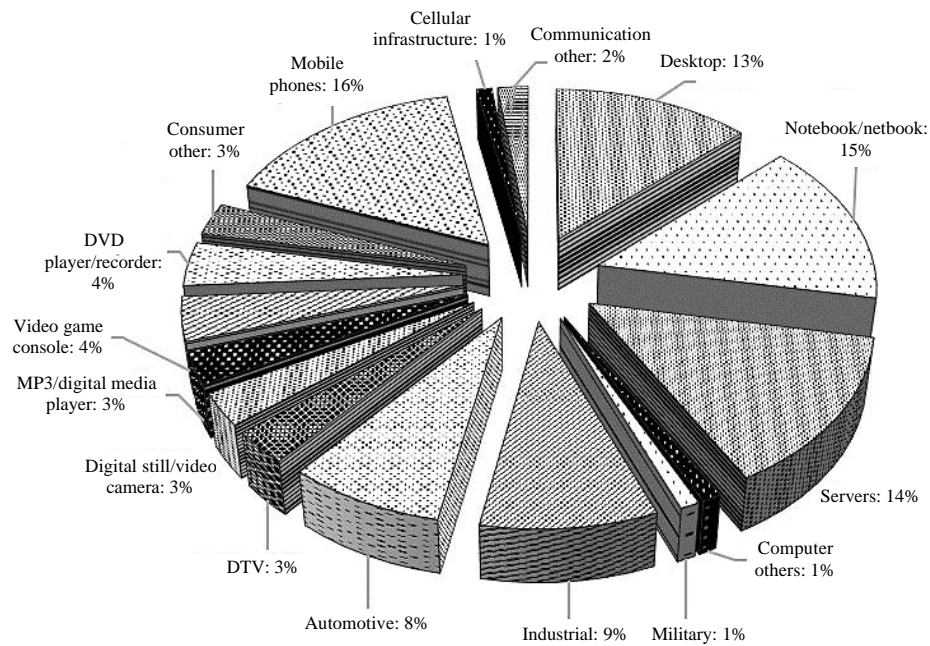


Fig. 1: The structure of global consumption of semiconductors

spacecraft and becomes more complex. And while China 30 years ago took the right decision and has been getting closer to the leaders of the electronic world from year to year, Russia after the collapse of the Soviet Union has been only falling behind.

The cause of the lagging development of Russian microelectronics is quite understandable: in Soviet times, the Soviet electronics industry was isolated from the world, products were competitive only in some “closed” market segments and there were virtually no funds for innovations in the protracted crisis of the 1990s. In addition when the Soviet Union collapsed, the old cooperation ties in microelectronics were destroyed but new ones were not established between the fundamental and applied science and the industry.

The global lag of the Russian industry has been partially reduced in the last decade. But it has become obvious that Russia has a surprisingly low level of the domestic microelectronics market. Therefore, there is not enough money for modernization, research, effective international cooperation and so on. By this indicator, we are even behind Hungary and in terms of the production output we are in the fifth ten of the world’s ranking.

But it would be too superficial to think that the main problem of the Russian microelectronics is only the absence of world-class production facilities. This plight is typical for the entire industry: from the production of raw materials to the assembly of electronic devices.

**Hypotheses:** The main objective of this study is to develop a national strategy for the development of a

high-tech industry-microelectronics. The main problems of the imbalance of the Russian microelectronics with the prevailing manufacture of products for the military industry are related to the research and development work underfunding which has been practiced for years, underutilization of possible instruments of state support as well as obsolete equipment, difficulties in turning discoveries and developments into specific products, i.e., the commercialization issues. The research addresses these conceptual problems, the solution of which is seen in:

- Comprehensive and sophisticated governmental support through the formation of a sustainable domestic demand for electronic products through localization of electronic components manufacture for the most part of equipment assembled in Russia and through public procurement
- Supporting and developing companies capable of taking fundamentally new niches in the world markets
- Improving the competitiveness of modern Russian enterprises through the creation of clusters which assume concentration of the entire production and process chain
- Promotion of more civil rather than military Russian goods designed using Russian-made microchips
- Developing the basic and applied science needed for the development of new technology and new equipment, so as not to miss the next round of the scientific and technological revolution in electronics

## METHODS

The study was written using the classical method of economic analysis-comparison. Comparison is the collation of the studied data and facts. Herewith, the comparability of the compared indicators which implies the unity of the periods of comparison, the measurement indicators, the calculation methods and so on is imperative. Researchers have resorted to different varieties of the comparison method:

Comparison with the past (the domestic microelectronics' status for the 1980-1990, 1990-2000 and 2000-2010 periods was assessed).

Comparison with the best (namely, global manufacturers of microelectronics in the USA and Germany by comparing the share of the microelectronics markets of individual countries in the global market. In addition, we compared labor productivity in this industry).

To draw up the structure of global consumption of semiconductors, we used the traditional method of economic statistics-the grouping method. The entire diverse market of microelectronic products was grouped into larger items such as industrial electronics, computers, car electronics, military engineering, mobile and cellular communication equipment, security systems and other consumer electronics.

In the formation of strategies for the development of Russian microelectronics in the medium and long term, the researchers used the method of forecasting based on expert information. As the expert opinions, we took into account the viewpoints of skilled Russian and foreign experts in this field, managers of leading specialized enterprises.

## MAIN PART

**Miniaturization of electronic components:** Among numerous technological problems to be solved to ensure further revolutionary development of the Russian microelectronics, the miniaturization of electronic components is in the first place. Reducing the size of chip elements entails a several times decrease in the price for one transistor. The increase in the number of transistors on a single chip results in the increasing number of functions performed by the chip which consequently decreases the cost of one function. Also, the desire for miniaturization-to <20 nm is associated with the increasing universality and performance of chips due to the increase in the number of transistors.

However, unlike the unit cost of a transistor and the functions performed by chips which decreases, the cost

of chips themselves as well as the process of their development and manufacture increases multiple times. Because of this, the number of companies that can afford manufacturing chips using the latest technology reduces. For example, the cost of construction of a factory producing 22 nm chips have increased approximately, 4 times compared to the construction of a factory for 130 nm chips (from 1.5-6 billion dollars). The cost of development of the technology itself has increased from 250-1.3 billion dollars and the development of an individual chip has risen from 15-150 million dollars.

As a consequence, the number of companies able to develop technology, equipment and chips at the most advanced level without assistance also considerably decreases. The following situation is currently observed: there are several dozens of companies that can run using the 90 nm technology, a dozen of companies can use the 45 nm technology but only a few-the 22 nm technology. As a rule they are concentrated in the United States (2-3 plants), Japan (1-2 plants), Taiwan and South-East Asia (3-4 plants), Europe (2 plants).

As for Russia, the Mikron Group is set to launch 90 nm production. Production using the 40, 32, 22 nm or less technology is required only for a certain class of products-microchips (including DSP), microcontrollers and memory. Nothing else requires such layout standards. The leaders in this sector have already been determined-Samsung for memory and Intel for microchips and chipsets for them. It is believed that the TSMC and Global foundries companies are enough to meet the demand for such contract manufacture. Therefore, it is a high risk to consider the idea of production based on the 45 nm technology in Russia.

**The Russian market of microelectronic products:** Thus, the second problem of the Russian microelectronics market is being formed-the limited number of orders and the inability to provide a full load of even a single production line of a modern plant. The country does not have a self-sustaining market-the population of 140 million people is not enough to create it. For comparison, the US company, Microchip Technology, since its foundation has produced >10 billion chips-more than people on Earth. It is no wonder since an average American home has >100 microcontrollers installed and another 50 are installed in an average American car. It was believed that the implementation of federal state programs for GLONASS and digital TV will create a market for the Russian component base but after years, nothing has changed.

The almost total absence of CKD assembly of electronics in Russia makes the situation with orders even

worse. Today, some of the exceptions are TV assembly lines in Central Russia and individual computer assembly productions which though do not have large output. Assembly can also be seen as a necessary component of any microelectronics cluster and its absence leads to negative consequences for the market. Surprisingly, the duty for assembly components is currently 5-10% while many finished products are imported into the country free of duty.

Another specific feature of the Russian market of microelectronics is the large share of public procurement. On the one hand, public procurement and public funding must be present in certain sectors of the economy. For example, India and China have a high share of public procurement. In developed Western countries, even if the relative share of public procurement in the business of large high-tech companies is relatively low (15-30%) in absolute terms, it is quite significant. In particular, the share of the annual budget of such companies as Boeing and BAE Systems related to the US defense order is quite comparable with the budget of an average state and is significantly higher than the entire Russian public procurement volume.

On the other hand, Russian government departments lack an integrated approach and funds are often dispersed with no hope of a return. Some managers believe that it is enough to install new equipment to make production ready for operation but it is not true at all. It is necessary to invest not only in equipment and technology but also in the marketing of new trends and in the infrastructure development (the quality of electricity supply of industry does not stand up to scrutiny) and the very establishment of the market to enable demand for Russian producers in the internal market.

At present, the development of the Russian market of electronics still faces many obstacles. For example, high interest rates on bank loans and expensive rental of industrial premises, high energy tariffs, inadequate insurance products and the high cost of insurance rates for financial and business risks (Skvortsova *et al.*, 2014). Dealing with foreign partners for the supply of components and materials is very difficult-it is impossible to conclude an agreement quickly. There are virtually no state standards. Inept management is another obstacle-sometimes, they determine the value of chips for the open market based on their value to the military-industrial complex and space technology which is almost an order of magnitude higher. The absence of publicly available statistics on the rate of development of the domestic market of microelectronics also has an adverse effect.

### **Strategies for the development of microelectronics in**

**Russia:** Thus, having identified the main problems of microelectronics in Russia, we need to identify the ways to solve them, to formulate the basic provisions of the strategy for the development of this sector, without which it is not clear how and where to move further.

First, the demand for and the market of microelectronic products should be created in Russia. In parallel, it is necessary to reform and improve the competitiveness of Russian companies on the domestic market. There are several possible scenarios:

**The first scenario:** Since Russia will fail to catch up with the whole world, we should not waste much money for the modernization of our own manufacture. We should specialize exclusively in fabless development (development without production facilities), not least because the foundries (contract manufacturing) in the world are loaded for 60-70% only. This line of developed was chosen by Belgium-a country that has never had its own semiconductor manufacturing but which today plays a key role in the global market of research and development.

**The second scenario:** Even with the five-generation lag and a huge amount of investment, we still need to have our own modern production facilities.

**The third scenario:** Russia should have at least one production center focused on dealing with multiple design centers, on small and medium series production. JSC "Angstrom-T" could become such a center as it fully meets the requirements of multiprocessing and has a modern set of tools needed to design information systems of any complexity.

Adhering to the last position, we note that the synergistic effect of the creation of clusters can considerably help establish the microelectronic industry. There are examples of successful microelectronic clusters in the United States, South Korea and Germany. Zelenograd is definitely the ideal venue for such a cluster in Russia with account of its production and scientific capabilities that have historically existed here. This cluster assumes not only regional concentration of the entire production chain but also presence of several chains competing and exchanging expertise and personnel. About fifty high-tech enterprises have already emerged around Zelenograd which cooperate in materials, equipment, design, research, training and infrastructure (Kutsenko, 2015).

At the same time Russia needs to take all measures to win significant niches in the microelectronics market. "In microelectronics, there are two main directions of development-low-power and high-speed microchips. By saying that we will never catch up with advanced microelectronics, we refer to either super high-speed or super low-power schemes. But there is a huge niche in between for any other applications. So, maybe it is not necessary to catch up with anyone but only to respond to the challenges of this niche", said Deputy Director of the Institute of Physics and Technology of RAS, a Corresponding Member of the Russian Academy of Sciences Vladimir Lukichev.

"A niche market but a very large one is the market of recognition systems. We are perfectly competitive with Israeli and German companies. In principle, this market alone is sufficient for the entire Russia to let its microelectronics live long and well. We have good results on space systems that we can proudly demonstrate both to America and Europe. And even the Mikron Group is seen by Europeans as "a factory that can serve for space needs" this is the opinion of President of the ELVIS Group of companies Yaroslav Petrichkovich.

Alain Astier noted that each region has its own singularities and niches and although "Russia is a very rich country with a rich population, it has not resolved issues such as transportation, security, medicine" which extensively apply products of microelectronics.

Along with the formation of the internal market, Russian companies need to make every effort to enter foreign markets. Here, the main thing is to find the niche, ensure the quality and regular deliveries of products and simplify the procedure for access to foreign markets. For example, the Micron Group makes every effort to bring the plates with modern RFID chips manufactured at the new 0.18  $\mu\text{m}$  production line to foreign markets.

**The government role in the development of microelectronics in Russia:** The government can be the only major investor that can play a decisive role in the development of domestic microelectronics. Public funding in the manufacture of microelectronics is indispensable, especially in the manufacture of chips. As part of the public procurement, Russia needs for its national security to maintain the production of those components (and accordingly, machinery and equipment), the stable import of which is not possible (for example, radiation-resistant electronic component base, encryption devices, etc.).

But the defense industry should not be the main driver of microelectronics. In the global market, the share of military information systems is low, for example,

compared to semiconductors for automotive electronics and communications: in 2010, its financial equivalent equaled to 1.1, 7.5 and 25%, accordingly. Here, with the price for military information systems is very high.

The government must focus not only on the public procurement and funding of certain companies but also on the development of rules and solutions in the field of machinery production. We believe that the government, first of all, should create markets, shape the tax policy and other conditions to encourage production, not just hand out money. Some developing countries including China which have been behind Western Europe and North America in the technological development, introduced special regional standards to protect their producers in emerging markets (e.g., cellular communications and digital TV markets). Multinational giants were forced to either participate in the development of the standard or abandon such a regional market. In any case, the winners were local producers of microelectronics and equipment. In Russia, the technology is usually completely taken over. For example, the readers installed in the Moscow metro operate under private standards of NXP Semiconductors (formerly, Philips); no initiatives to protect the gaining momentum digital TV market are present (the capacity is 58 million receivers), etc.

As a result, the problem of loading domestic manufacturers and design centers is largely shifted to the state which in turn can form the market by orders. The already mentioned Moscow metro tickets that are required in the number of about 20 million per month today are an important part of the production program of the Mikron Group.

As mentioned above, currently in Russia only selected areas of microelectronics industry are competitive which are mainly related to military production. To stimulate the microelectronics market, it is necessary to focus on promoting Russian civilian goods that are based on the use of Russian-made microchips. First of all, this relates to using them in passport and visa documents, migration, transport, payment and other cards.

The National System of Payment Cards (NSPC) which was established in the Russian Federation in 2014 to ensure the continuity, efficiency and accessibility of money transfer services, could become a potential market for domestic microelectronic products. The need to create a national payment system has been discussed for >20 years but the solution of the issue was expedited after the imposition of sanctions which suspended the service of renowned international payment systems cards issued by some Russian banks. Thus, the process of payment cards issue that is being implemented within the

framework of Russia's launch of the national payment system will create a certain niche in the market for domestic microelectronics (Rakhlis *et al.*, 2014).

**The program of electronic industry development:** One of the positive facts that can be seen as encouraging in terms of the soonest formation of the microelectronics industry in Russia is considered the development of a new program for the development of the radio electronic industry. The program is planned for the 2013-2025 period. The main goal pursued by the implementation of this program is to improve the competitiveness of the Russian microelectronics industry through the creation of an infrastructure for the development of top priority lines of integration into the global market and the innovation potential implementation.

The state program of radio electronic industry development is divided into three stages. The first stage (2013-2015) provides for the creation of conditions for the industry development; the second one (2016-2020) assumes active promotion of the launch of new projects; the third one (2021-2025) commits a transition to supporting the production growth. Implementation of all three stages assumes coordination with the national innovation development centers: Skolkovo, Rusnano and VEB.

The total budget for the state program will be 517 billion rubles. The federal budget allocates 178 billion rubles. The program includes such trends as consistent reduction of public funding, increased private investment, implementation of the cluster policy, a focus on small and medium-sized enterprises, creation of a competitive environment.

With the implementation of the state program of radio electronic industry development, the focus should be made on the top priority sectors: energy efficient systems, automotive industry, medicine, security, industrial electronics in which Russian enterprises have technological, industrial and intellectual capacity. Herewith, domestic microelectronics must replace imported ones in the industries in which it is necessary and permitted by agreements with the WTO. Thus, the creation of databases of microelectronic components for space, passport and visa documents and special purpose components needs to be implemented through public funding. Unfortunately, the program is currently suspended due to the difficult economic and financial situation in the country but experts hope for its resumption that will help Russian microelectronics to achieve a higher level of development.

But even if all program items are fulfilled-the most modern factories are built, a system of design centers

is created, localization of production of electronic components is achieved and new niches in the market are won-we cannot fully escape from technological dependence and the risk to fall behind will always exist as soon as a new technological wave gains strength. According to many practitioners after 2020, microelectronics will face a change in the technological paradigm.

The breakthrough capacity is only left in the areas that have just started to be developed. These are nanoelectronics as well as organic, fullerene, graphene and other semiconductors. Yaroslav Petrichkovich says: "All germs of new technologies should be immediately developed and promoted. There are few of them in fact. We need to create an infrastructure around them and involve universities". Russia needs such a center for development of new industrial technology and equipment for them. It can be built by just finding people-scientists, engineers, designers-who have world-class ideas and supporting them in every way, turning them into future general designers.

In addition, we must decide what preferences are needed by domestic producers of microelectronics in public procurement tenders and consider additional incentives including tax and customs. For example, it could be the simplification of import and export of spare parts and consumables for the production of microelectronics, instrumentation, process equipment as well as the abolition of import duties on these materials and equipment.

## CONCLUSION

The absence of a high-tech products market is a serious problem of the Russian economy. There can be much debate about what should be first-innovation or the market-but there is no doubt that if these two guides do not intersect, the economy will not develop. The sooner Russia has a clear and consistent plan for the development of microelectronics supported by the government, the greater the chances to shift the Russian economy from the "raw" to "high-tech" type are. Summarizing all the above, we come to the following conclusions:

The semiconductor industry is a driver of innovation, social progress and other industries and the country's economy as a whole. In the modern world, the state of microelectronics directly influences on the technological independence and security of the country as well as the country's modernization. Electronic components are present in all domestic, industrial, defense products,

ranging from SIM cards of mobile network operators, bank cards and to the most modern weapons. The current situation in Russian microelectronics can be called “a severe technological lag”.

The problems faced by the microelectronics industry today are: miniaturization of electronic components (chips are produced in the world under the 14 nm technological process and in Russia-90 nm), a limited number of orders and the inability to ensure full loading of a modern plant, no screwdriver assembly of electronics in Russia, bureaucratic barriers, high production costs, etc.

To develop microelectronics, it is necessary to form the demand for and the market of microelectronic products inside Russia. Along with this, Russian companies need to make every effort to enter foreign markets and win serious niches. These steps in the development of microelectronics in Russia will be

more confident if there is effective and well-thought-out financial and organizational support of the government and guaranteed sales volumes.

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