Rationale of the need to the development of semiconductor industry in Russia with the 28 nanometer semiconductor device fabrication node and below

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Abstract. This article describes the systemic problem of the development of the Russian semiconductor industry due to the lack of national production of integrated microcircuits with topological standards below 65 nm. Here are the results of the analysis of the feasibility of production lines of integrated circuits developing, depending on the forecasted volume of demand for various categories of semiconductor products, the technological backlog of Russian organizations and the estimated cost of the project. In this article, there are suggestions on possible sources of project financing and measures of non-financial support. Also, it describes the general technological parameters of the created production. It contains an assessment of key performance indicators of the project and the impact of its implementation on related technological areas.

1. Introduction
If we talk about the changes taking place during the last decade in the scientific, industrial and social spheres, it should be noted that most of them are related to advances in information technologies [1]. Moreover, the formation and distribution of such a cyber-physical system as the Internet of Things, predicted by leading analytical communities, will lead to further growth of sales markets and stimulation of the development of semiconductor technologies [2], [3]. The accumulated economic effect on a global scale for the period 2016-2025 is estimated at $12.8 trillion [4], for Russia this value for the same period can be from 70.1 to 153.5 billion dollars [1].

Digitalization of the economy, especially - industry, the administrative apparatus and defense industry involves the introduction of systems that allow information flows managing, through which direct influence on the functioning of physical systems is possible. This circumstance determines the strategic importance for the country's security of development of the national semiconductor industry, based on semiconductor production.

At the same time, it should be noted that the systemic problem of the modern national semiconductor industry is the closure of the scientific and production activities of industry organizations in the market’s segment of defense industry. This circumstance determines a number of restrictions imposed on applicable models of the industry development in the medium and long term planning (up to 15 years).
2. Analysis of current situation

In the defense industry labor productivity is significantly influenced by a high level of requirements for reliability, the number and types of products tested. It should also be noted that military products have low seriality level, which imposes limitations on the possibility and rationality of the level of automation of the process of its creation. Due to the influence of these factors, much more man-hours are spent on the production of military products than in civil products, where production processes are much more unified and automated. As a result, the level of labor productivity, other things being equal, in the military industry will be significantly lower than in the civilian for the above reasons.

Support for the development of semiconductor product lines for advanced topological standards has an extremely high capital intensity (see Figure 1). Taking into account that labor productivity in the largest Russian semiconductor industries in 2016 did not exceed 4 million rubles per person per year, it can be concluded that those semiconductor industries, which focused on the production of military products are unable to ensure independent technological development.

![Figure 1](image_url)

**Figure 1.** The cost of developing various models of semiconductor production

With the current world level of topological standards of 10-7nm on 300mm plates, the most advanced level available to Russian science is 65nm. Insufficient range of the microchips production technologies hinders the development of the industry.

At the moment, Russian design centers are already developing integrated circuits for 28nm and below technologies. They are forced to place their orders on the largest world factories (TSMC, GF SMIC, etc.). At the same time, the demand for semiconductor products with a technological level of 28 nm and below has already been formed and will only grow (see Table 1).
Table 1. Potential demand for Russian design centres the technology level of 28 nm and below.

| Technology | Production Volume | Product Type |
|------------|------------------|-------------|
| 28 HPM     | 2 millions of IC per year | Processors |
| 16 FFc     | 5 millions of IC per year | Processors |
| 28 HT/ 22 FDx | 0,1 millions of IC per year | Processors |
| 28 HPP     | 2 500 pieces of wafers / 300 mm per year | PC, routers, network equipment |
| 28 HPP     | 5 170 pieces of wafers / 300 mm per year | Processors, multiprocessor servers |
| 22 FDx     | 8 000 pieces of IC per year | DSPC |
| 22 FDx/ 14 nm | 4 000 pieces of IC per year | Radiation-resistant SoC |
| 28 nm      | 2 000 pieces of IC per year | Multimedia VLSI |
| 22 FDx     | 500 pieces of wafers 300 mm per year | Processors |
| 28 nm      | 200 000 pieces of wafers / 300 mm per year | IC for meters |
| 28 HPM     | 800 pieces of wafers / 300 mm per year | SoC for telecommunication devices |
| 28 HPM     | 5300 pieces of wafers / 300 mm per year | SoC for personal devices |
| 16 FFc     | 600 pieces of wafers / 300 mm per year | SoC for server devices |

According to world trends in 2017, the most of the silicon wafers were produced using technologies 28 nm and below (see Figure 2).

Figure 2. Distribution of silicon wafer production by technological level.
Table 2 shows the estimated cost of the project, taking into account the existing technological reserve of leading Russian semiconductor companies.

| Cost category | Cost of work |
|---------------|--------------|
| R&D           | 8%           |
| Operating expenses | 7%   |
| CMP*          | 37%          |
| Equipment     | 48%          |
| **Total:**    | **from 55 to 80 billion rubles.** |

3. Result and discussion

In order to ensure a sustainable long-term development of semiconductor production in Russia, it is necessary to form a set of regulatory and legal measures. A key condition for achieving profitability of production is the provision of direct state and quasi-public demand for the products of the factory (see Fig. 3).

**Figure 3.** Solution of key tasks for the development of semiconductor industries in Russia

It should be noted that after the stage of construction and adaptation of technology, which is estimated to take 4 to 5 years, depending on the technology chosen, the first 1-2 years the basis of revenue will be military and dual-use products and only after that by 2023-2024 it is possible to exceed the share of
orders of a civil character in the general order book of this factory due to the conversion and development of civil semiconductor production in Russia.

If we rely on the analysis of companies that currently have a technological process of 28 nm or below (see Figure 4), potential technological partners were chosen to create a semiconductor production with a 28 nm technological level on 300 mm diameter wafers, taking into account geopolitical and economic factors, companies represented in Table 3.

**Technology leaders in the development and production of chips.**

**Table 3. The list of potential technological partners.**

| Company       | Country      | Type of company  |
|---------------|--------------|------------------|
| UMC           | Taiwan       | Foundry          |
| GF            | USA / UAE    | Foundry          |
| Imec          | Belgium      | Science Center   |
| SMIC          | China        | Foundry          |
| ST            | France / Italy | IDM             |
| Samsung       | Korea        | Foundry          |
| TSMC          | Taiwan       | Foundry          |

4. Conclusions

According to the analysis of international experience, it can be argued that even with full government funding and the full required set of regulatory and legal support measures, it is highly likely that the best result of the factory's operations will be the achievement of a break-even point.

Nevertheless, this project will be strategically important, being the basis for carrying out the policy of import substitution in civil products, the creation of national cyberphysical systems, equipping state institutions and departments with trusted equipment.

Also, this project will be especially important in the field of preservation and development of the human resources potential of the Russian semiconductor industry, which is one of the most highly qualified and difficult to recover in the economy.
References

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