ISSN 1804-4158

# THE MOST IMPORTANT DIRECTIONS OF DEVELOPMENT OF TECHNOLOGY CONVERGENCE AND THE BASIC SCOPE OF NANOPRODUCTS

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**ABSTRACT**

The author investigated the evolution of the process of production in a nanosphere, analyzes the features and achievements of production units of nanotechnology, nanomaterials and nano-products in various sectors of the Russian economy: electronics, medical and pharmacological industry, genetic engineering, production of construction materials, electric power industry. Considered sectoral and regional distribution of particular nanotechnologies and nanomaterials. Allocated Rupp leading countries of the nanospheres. As the proliferation of nanotechnology leaders selected USA, Japan, Germany and South Korea. In the next group of countries with high development of nanotechnology, with a lower level of activity states - Israel, Singapore, the Netherlands, Sweden and Switzerland. The next group consists of France, Britain and China, where the level exceeds the level of real nanoaktivnosti nanotechnology. Based on the Letter of the world and practice, the author of the nanotechnology sector is estimated to be the most attractive to venture capital. The problem lies in the expansion of the Russian practice of attracting foreign venture capital to fund research. One of the most realistic solution to this problem is in the framework of the strategy of cooperation between science, business and government, to accelerate the transition of technologies from laboratory to industrial nanomaterials from fragmentary studies to design innovation.

**UDC & KEYWORDS**

■ O33 ■ NANOTECHNOLOGY ■ NANOMATERIALS AND NANOPRODUCTS ■ NANOSPHERE ■ THE CONVERGENCE OF TECHNOLOGIES

## INTRODUCTION

Nanotechnology, nanomaterials and nanoproducts - factors of a new stage of scientific and technological revolution, and thus - the economic development of innovation in Russia. Nanomaterials and nanoproducts to made to attribute material the size of nanoscale ($10^{-9}$) (Balabanov, V. &Balabanov, I., 2010) , which arises exists a new quality and this quality appears in the composition of nanoobjects, and production technologies - to nanotechnology (Alferov, Lseev, Gaponov and others, 2003).

Historical reference point of the scientific use of nanotechnology is the discovery of Russian theoretical physicist G.A. Gamow, who in 1928 obtained a solution of Schrödinger equations describing the possibility of overcoming the energy barrier of the particle when the particle energy is less than the height of the barrier. The phenomenon, called tunneling, possible to explain many of the processes in atomic and nuclear physics, form the basis of a number of advanced technologies, including nanotechnology. The development of electronics has led to the use of tunnel diodes and tunneling microscope, which allows to construct three-dimensional picture of the arrangement of atoms on the surfaces of conducting materials. Tunneling microscope was founded in Zurich Research Center IBM physics Gerd Binning and Heinrich Rohrer. The scanning probe atomic force microscope allowed us to visualize the atoms of any materials, to manipulate them and collect them into new substances.

Decisive role in the development and establishment of nanotechnologies played the opening 1991 fullerenes - molecules, which were used to create carbon tubes used for the production of materials, higher strength steel in the hundreds. On the basis of the nanotubes used as molecules, Cees Decker in 1998 created a transistor by combining carbon nanotubes with DNA and received a single nanomachines.

Since the mid-90's development trajectory of nanotechnology enters the growth phase - begins a rapid increase in the number of publications on the topic of nanotechnology, as well as the use of nanotechnology methods in the industry. This was made possible thanks development of methods and means of linear measurements and manipulation in the nanometer range, which actually provided the technical possibility of creating nanotechnology.

These developments have opened new properties of matter and create materials with predetermined properties, possibility penetrating due to manipulation of the atoms of matter on to the nanolevel: decode genomes of plants, animals and man, invented the cloning technology and genetic modification of living organisms; open stem cells to develop cell technologies in medicine.

Together these basic innovations form clusters of complementary, technologically conjugate production, to the extent that contribute to the development of the reproductive circuit of a new technological system, which is a key factor in nanotechnology.

Consider the most important directions of development nanotechnology, which are grouped according to main areas: electronics, medicine and pharmaceuticals, genetically modified products, structural and functional materials, mechanical engineering, power engineering.

### Electronics

While the growth path of the new technological order still forms, there is intense competition of different technical solutions offering their firms and teams of scientists, as well as a fight between the two countries for leadership in the formation of the nucleus of a new technological order. A typical example of such a competitive struggle is the creation of new technological trajectories in the electronic industry. The competition of modern microprocessor technology forces manufacturers to improve the performance of processors, increasing memory capacity, reduce the size of devices and makes them cheaper. As the main technical characteristics of electronic devices is largely determined by the size of electronic components, minimization has become the general direction of the trajectory of technological development in microelectronics,

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has seized all the components of the process - lithographic equipment, including excimer laser, optical system, image transfer, positioning systems, scanning and matching plates and photomask . More than forty years the general trend defined by the so-called Moore's Law, whereby the density of the components of integrated electronic circuits doubles every eighteen months for the (or the size of the circuit elements is reduced by half).

As a result, in the early twenty-first century this size is entered nanoregions (reached 100 nm). Go abroad this technological trajectory of the sixth phase of the technological order of maturity should be considered as the development of a range of extreme ultraviolet radiation of wavelength 13 nm.

Process contingency already established industries makes synchronizing complementary and mutually supporting each other's innovations. For example, release a small amount of chips for super electronic computer allows you to create computational tools for system-aided design aircraft and shipbuilding. This, in turn, creates the possibility of designing sophisticated equipment and, hence, increases the demand for chips. This kind of feedback with a strong positive effect form the trajectory of growth in the new technological order. Technological renewal is accompanied by a rapid increase in efficiency and production intensity simultaneously with the increase of its capital.

Dynamics of development and dissemination of nanotechnology in the electronics industry illustrates the break-up forming the nucleus of a new technological trajectory of technological order.

If the initial phase of its life cycle, when the scope of the technology is very limited, and the corresponding technology base is being formed, the cost of investment in building capacity is small, then as the deployment of technological trajectories rapidly growing volumes of both production and investment, the efficiency rises sharply production, allowing you to finance further development.

At the same time leaders are rapidly increasing their technological superiority, and the entrance to this technological trajectory for new proving increasingly costly and economically risky.

New production is much less energy and materials than the previous structure. Typical example of a rapid increase in the efficiency of energy consumption with the growth of new technological order is distribution of LEDs in lighting technology. LED, semiconductor, which is based on the physical phenomenon of light emission during the passage of electric current through the junction between two semiconductors. Unlike incandescent light-emitting diodes emit light in a relatively narrow band of spectrum. They occupy an intermediate position between the lasers, which are monochromatic light (light with a well-defined wavelength), and various types of lamps that emit white light (a mixture of different radiation spectra).

As sources of colored light emitting diodes have long surpassed incandescent lamps with filters. LEDs are widely used as indicators of miniature audio and video equipment and household appliances. Except for high luminous efficiency, low power consumption and the possibility of any color light, LEDs have a number of other remarkable properties. The absence of the filament due to the nature of nonthermal radiation of LEDs results in long service life. Manufacturers declare LED lifespan of up to 100 thousand hours or 11 years of continuous operation (Glazyev, 2010). The absence of a glass bulb defines a very high mechanical strength and reliability. Low heat and low supply voltage ensures a high level of security, and inertialess makes LEDs indispensable when you need a high speed (for example, the stop signal).

LEDs are becoming more widely used: the active lights and traffic signs, cars, cell phones lighting, illuminated signs, full color LED displays much more. LED dynamic color system, easily programmable from the remote computer or personal computer, are used in architectural and landscape lighting. If you look into the future, lighting LEDs is converted to the creation of light color environment with fully managed spatial, brightness and color settings.

Developed countries in the next few years plan to completely abandon the incandescent lamps, which will be replaced with energy-efficient LEDs. In the same direction of new standards for energy efficiency work in homes.

At the beginning of their life cycle, the LEDs on the inferior performance indicators to traditional light sources. But the trajectory of technological improvement is far ahead of other LED light sources on the efficiency of conversion of electricity into light.

Over the past eight years, with growth rates exceeding 30% per year, the world market reached a level of light-emitting diodes in the 3-4 billion dollars in 2007 is expected to reach the market for LEDs $ 5.4 billion by 2013, and by 2015 - 5.9 billion dollars according to reports the company Strategies Unlimited, studying the market for LEDs, its continued steady growth is expected in the next 5 years, regardless of the progress of the global economic crisis (Glazyev, 2010).

The main manufacturers of LEDs and devices based on them are companies in Japan and the USA. Rapidly growing production of LEDs in the South-East Asia, especially Taiwan, South Korea and China. The Russian market today, LED is about 100 million units per year and more than half of them are bought abroad. Along with a few producers in the world, Russia has the technology of manufacturing ultra-high brightness LEDs that are directly used for lighting homes. In the case of replacement bulbs in various fixtures to LEDs by 2012 the world market LED lighting could exceed $ 60 billion a year. The Russian market could reach 70 billion rubles. And by 2012, domestic production of nanotechnology must play a decisive role in it.

The most rapidly growing part of the semiconductor industry is the market microelectromechanical systems. The average annual growth of this sector over the next five years could exceed 66 billion dollars, which amount to 15% of the total semiconductor market (Kononov, 2008).

More recently, the driving force behind the market was microelectromechanical systems automotive electronics, where the technologies are widely used. Thanks to the opportunity to accelerate the creation of sensors, is now installed in almost all modern cars for the detection of the collision and release of protective airbags. In addition, the heads are made mikrostruynyh printers, pressure sensors, provided medical and automotive industries, high-resolution digital projectors, etc. In recent years, considerable progress has been achieved in the manufacture of motors, pumps and other various mechanical assemblies for the purpose, invisible to the naked eye. The scope of consumption nanoelectromechanical systems captures the consumer sector: remote control, multimedia phones and portable storage on magnetic disks. MEMS devices are necessary to protect the hard disk from damage if dropped, and laptops - to turn in the case of theft. MEMS devices are being developed optical switches for fiber optic telecommunications systems. MEMS technology is now

a promising technology of production in excess of high frequency devices.

The development of the communications industry through the application of nanoscale heterostructures has led to advances in excess of high frequency devices for electronics, ensuring the creation of high-speed devices, the dominant communication systems, radar, radiometry, navigation devices in the fight against terrorism, as well as modern electronic means of arms. Achievement of the minimum feature size (gate length transistor) - 30-50 nm - provided a quantum leap: the creation of super high frequency devices with a range of frequencies above 1000 GHz.

The transition from transistors in nanoelectronics to the heterostructure nanotransistors provided a manifold increase in speed, the transition from the centimeter range of wavelengths to the millimeter and submillimeter ranges, respectively, and increased velocity and volume of information transmitted in the The volume of global sales heterostructure transistors and monolithic integrated circuits have approached the 7-8 billion dollars per year, increasing annually by more than 30% of the most massive scope nanoheterostructures technology is cellular. It takes about 57% of the heterostructure of the market. Heterojunction transistors include cell phones. About 23% of the market is a fast-high-speed fiber-optic communications (Alferov, 2004).

One of the basic inventions using heterostructures with nanoscale layers is the creation of high-performance lasers. In Russia, the main research in this direction are carried out at the Physico-Technical Institute. AF Joffe, Russian Academy of Sciences and the Institute of Semiconductor Physics. The use of nanotechnology can improve the quality and increase the efficiency of semiconductor lasers, LEDs and lighting systems based on them.

In Russia a modern industrial heterostructure technology does not exist yet. The commercial market is not formed, the defense dominated the state order, as it was in the advanced countries in the 80s.

Only the most technologically advanced states (USA, Japan, Germany, France, Korea, and Taiwan) have full technological complex enough to produce various types of such devices. Applications of semiconductor lasers are very diverse and include optical recording device, data storage and retrieval systems, fiber-optic communications, sensors of various types. The use of electromagnetic terahertz radiation is harmless to humans, which opens up wide possibilities for application of laser technology in medicine.

In Russia, despite the difficulty of funding research saves par with developed countries in all major areas of development of laser diodes. It is expressed in the achievement of world-class options (including - a record) for devices made in small batch production or laboratory. The total Russian market of laser diodes is estimated at 8-12 million dollars per year with annual growth of 8-10%, which corresponds to global trends (Glazyev, 2010).

The use of semiconductor nanoparticles and nanowires has created over shortwave lasers (nanolaser), promising to increase the density of optical discs in dozens of times. The short-wavelength laser with a wavelength of 5-50 nm can be used in new types of optical microscopy and high-resolution lithography, necessary for the creation of micro-and nano-electronics new generation. If you change the red lasers used today for recording CD systems, the nanolaser recording density increase by more than a thousand times.

In recent years, attempts to develop on the basis of nanolasers optical computers, which are replaced with modern electric machines. In turn, optical computers are a starting step toward more complex quantum computers.

As a real alternative to the "silicon" electronics in the near future, many experts considered the molecular electronics. Nature has created over millions of years of evolution of a variety of molecules that perform all the necessary functions of a complex organism: sensory, logical, analytical, storage, movement. They have the optimum configuration, structure and nanometer size. The largest to date with the electronic density of addressable memory is created through the use of molecular sieves. This achievement opens the way to the creation of complex chips, the size of a few molecules, which are improving in the future will get even smaller, faster and cheaper devices.

A promising direction of development of electronics in determining the progress of information and telecommunication technologies in the next 10-20 years is the transition from binary logic to a neural network techniques in continuous processing of information distributed molecular and biomolecular environments using as a carrier of information luminous fluxes. Combining advances of nano-and bio-molecular technologies provides a fundamentally new materials for specialized components of neuro-computers, and intelligent robotic systems capable of autonomous learning and the successful follow-up work in difficult environments.

**Medicine and pharmaceutics**

An important part of the scope of nanomaterials and nanotechnologies are nanobiotechnology, combining the achievements of physics, chemistry, biology and medicine. On the basis of their diagnostic systems are being developed highly dispersed form of drugs and their targeted delivery to the affected organs are biocompatible materials and coatings for use in medical implant practice reconstructive and plastic surgery. Mastered the industrial production of test kits for the rapid determination of socially important agents of viral and bacterial diseases, toxins and crop pests. The technology for producing nano-based diagnostics encapsulated quantum dots, metal nanoparticles to develop new rapid and inexpensive analytical methods for decoding the sequence of nucleic acids and proteins to meet the needs of medicine, agriculture, national security. In recent years there has been rapid growth in sales of medical products using the technology of genetic engineering.

Genetic engineering technology can synthesize drugs with known properties, in contrast to traditional pharmaceuticals, which is to develop new drugs have to investigate the properties of tens of thousands of different chemical substances. With new approaches to drug development in recent years have witnessed revolutionary breakthroughs in the treatment of diseases such as cancer, multiple sclerosis, rheumatoid arthritis, diabetes, etc.

Novel nano-vehicles for drug delivery to the target organs. These developments will improve the solubility, bioavailability, therapeutic possibilities of drugs, reduce the dosage and side effects, significantly reducing the drug burden on the body. A large spread of these technologies are found in the field of cosmetology, as obtained in this way liposomal cosmetic products have excellent potential for transdermal penetration.

The application of nanotechnology can raise to a qualitatively new level of effectiveness of many types of medical activities. In particular, they allow you to create

materials with enhanced biocompatibility with blood, and the living tissues of the human body with saline. The demand for implants for cardiovascular surgery is estimated around 4 million units per year. Formation of biocompatible interfaces between medical material, the implant with the living components of the human body (blood, plasma, saline, lymph, etc.) involves the creation of the morphological structure of the surface of the implant with the size of the surface active elements, which correspond to the size of the structures of these living components, that is, nanoscale range.

The connection of nanotechnology and genetic engineering advances offers revolutionary possibilities for regenerating tissues. To create a bio-artificial organs and tissues used by carriers for cell-based nanoparticles. One promising avenue is the use of stem cells. Stem cells develop into specialized cells as needed growth and regeneration of the tissues. Previously believed that the source of stem cells is the embryonic tissue and bone marrow of adult humans. However, were subsequently found inexhaustible supplies of stem cells in adipose tissue, which lifted the ethical and medical barriers to their widespread use.

It is expected that the use of genetic engineering advances will repeatedly increase the efficiency of health care and pharmaceutical industries. The main directions of development of nano-bio-industry in the next five years, determined by the development of micro-and nano-fluidic technology for precise dosing technology of biochemical reactions in micro-and nanovolumes and technology to read these signals and transforming the signal into a sequence of nucleic acids.

**Genetically modified foods**

Another area of nanobiotechnology has been the rapid spread of agriculture, which are widely used genetically modified organisms created by genetic engineering techniques based on the achievements of modern molecular biology. Under the definition of genetically modified organisms are subject to changes in the genome, which can not be achieved by traditional methods of selection and recombination. The most common genetically modified bodies today are the transgenic plants, which are introduced into the genome of foreign genes to give it new properties. For example, set up a potato, a gene having a ground bacteria, which gives it resistance to Colorado beetle.

First of agricultural genetically modified crop was a tomato that is resistant to decay. During the period since 1996, when the commercialization of genetically modified crops were introduced in many countries and by 2007 held more than 114 million hectares. The greatest amount of acreage, about 50% of global area, planted in the USA, approximately 90% of the acreage in Argentina, Brazil and Canada are busy genetically modified crops (Glazyev, 2010).

Formation of the trajectories of the production of nanomaterials and nanotechnology in crop growing is now stable. Market contributed to the selection of the most competitive plants, produced through the use of genetic engineering in the cultivation of which the maximum economic benefit. Although the number of patented crops growing, the vast majority of crops accounted for soybeans, cotton, corn and canola.

**Structural and functional materials**

The use of nanocomposites leads to the creation of new types of materials that combine high strength and ductility. Increased performance due to the formation of nanocomposite materials during sintering specific continuous filamentary structures formed by three-dimensional contacts between nanoparticles of different phases. Improved corrosion resistance of nanostructured coatings is due to reduced concentrations of specific impurities on the surface of grains of MEE to reduce their size.

Among the most promising and widely studied nanomaterials with a wide range of applications include fullerenes and carbon nanotubes. They form a new class of carbon nanomaterials, or carbon frame structures, with properties that differ significantly from other forms of carbon such as graphite and diamond.

Commercial introduction of carbon nanotubes is carried out in the field of electrical energy storage (hydrogen fuel cells), high-capacity capacitors, devices with a good electron emission (displays, electron microscopy, scanning probe microscopy, etc.), production of aggregates for the anti-friction pads, working in the aviation and automotive engines, filling in various bulk nanocomposites (from carbon fiber to the multicomponent ceramics). These bulk materials will be used in automotive, aviation as structural materials for special applications. The development of materials and coatings based on nanotubes to reduce friction in electromechanical devices. Currently the main areas of application of carbon nanotubes are sporting goods, electronics and automotive. Carbon Nanotechnologies can be used in electronics for the absorption of microwave radiation, to create new materials with controlled electromagnetic and even superconducting properties. Nanotubes can be part of compact integrated circuit.

One promising avenue is the use of nanoceramics having improved characteristics: high strength and hardness, lightness, elasticity, high electrical resistance, low thermal conductivity.

The last 2-3 years the retail market of imported and domestic anti-friction products, reducing wear and reducing friction surfaces show strong 50% growth, which will continue in the foreseeable future. Its capacity is 750-900 million rubles a year.

Back in the 60-70s of the twentieth century. Scientists from many countries have studied the effects of new, clearly manifested in the fine grinding of materials. When the particle size of crushed material fall into nanoregions, there are fundamental changes in physical and chemical properties (amorphization, chemical activity, high solubility, the solubility of insoluble substances, etc.).

Industrial production of most types of powders (metal oxides and powders of pure metals) is relatively recent. Prior to that produced in commercial quantities only silica, alumina and iron oxide. Research institutes and universities, released in small amounts, many of nanopowders is now available for use in nano research. Despite the wide range of currently available nanopowders, only some of which are produced on an industrial scale and are subject to competitive pricing.

In a variety of publications deal with such applications of nanopowders as increased strength and hardness of materials, making electrical insulators, the optimization of combustion catalysts and reagents, reduction of friction, magnetic materials, protective coatings, optics, abrasives, radio, filters, electroplating, electronics, pyrotechnics, cosmetics, colored glass, etc. While not all manufacturers of powders, not to mention their potential consumers, a good representation of how to use them.

Such industries as electronics, optics, manufacturing, consuming more than 70% of the production of nanopowders. Medicine and cosmetics industry - about 7% of nanopowders. It is expected that their use in this area will

lead the majority of nanotechnology research in the next 10-15 years.

Currently, the database of nano substances produced in the world, contains information on more than 1,400 substances, divided to 22 areas of application (Glazyev, 2010).

Development work in the field of nanomaterials and measuring in the nanometer range can have a revolutionary influence on the development of mechanical engineering. One of the main problems in engineering is the creation of new machine tools for machining of parts up, lying in the nanometer range. These machines are needed in missile and aircraft construction, space industry, as well as for processing of optical components for various purposes. Created with nanotechnology methods of measurements provide the ability to adaptively manage of cutting tools based on optical measurements of the workpiece and the details of the tool surface directly during the manufacturing process.

**Energy**

The direction of solar energy - one of the promising applications of nanotechnology. Energy from solar radiation many times the industry needs for energy. The main obstacle to the development of solar energy converters based on semiconductor - high cost. The use of nanomaterials and nanotechnology allows multiple enhance the effectiveness of solar energy through the use of nanostructured photovoltaic cells. Recently developed cascade solar cells provide a high coefficient of efficiency. In space - up to 33%, the silicon cells - 15%. The increase in the proportion of solar energy to 300 W/m2 at a flux of solar energy - 1400 W/m2.

No less important is the task of creating effective on organic nanomaterials cheap converters of solar radiation in the form of thin flexible panels covering the walls and roof of the premises. Cheapness of materials and technology could make solar energy cost-effective even for solar energy conversion factor of 5-7%.

The market for solar energy is developing rapidly in recent years. The total market size in 2008 reached $ 33 billion, or about 5 GW. Since 2001 the market in value terms increased by more than 11 times. The market for silicon thin-film solar modules in 2008 was estimated at 0.6 GW by 2012 it will increase to 2.4 GW in terms of money - from 3.8 billion to $ 8.6 billion.

Nanostructured materials can be used to increase the capacitance of the electrodes, the ionic conductivity and long-term stability of electrolytes, as well as improve the efficiency of the catalysts of electrochemical reactions at the electrodes. For example, nanostructured foils can significantly improve the technical and economic parameters of electric capacitors. In addition to improving the performance of aluminum electrolytic capacitors with liquid electrolyte, nanostructured anode foil can be used in advanced solid aluminum capacitors, whose production in recent years has become one of the priorities of the majority of the world's leading companies that manufacture radio-electronic components.

**Sectoral and regional distribution of the features of nanotechnologies and nanomaterials in groups of leaders nanospheres**

Analysis of the results of the spread of nanotechnology is very difficult due to the relatively small size and lack of sufficient statistical data. Only after the restructuring of the economy and create conditions for the growth of the scale of nanomaterials and nanotechnology in the production performance of their distribution will be important parameters of the management of economic development.

The leaders of the spread of nanotechnology are USA, Japan, Germany and the Republic of Korea. The next group of countries with high levels of development of nanotechnology, but a lesser degree of activity of the state are Israel, Singapore, the Netherlands, Sweden and Switzerland. The next group is made up after them, France, Britain and China, whose level of activity than the nano level of real development of nanotechnology.

However, in all countries in the weight of the nano-structure of gross domestic product is less than 0.1% of world gross domestic product. Of course, the overall impact of nanotechnology on the economy is much higher and should be evaluated on the basis of applications of this product. The process of their distribution only enters a phase of growth.

According to Lux Research, the share of nanotechnology by 2014 will increase from 1 to 4% of industrial output. With the use of nanotechnology will produce 100% of the computers, consumer electronics 85%, 23% and 21% of pharmaceutical vehicles (Glazuev, 2010).

Experts Global Industry Analysts, Inc., Estimated growth in the global market for nanomaterials that period to $ 10 billion is expected that the most important growth factors may include: expanding segment of manufacturing carbon nanotubes, nanomaterials production growth of 11.7%, nanoinstruments 33, 3% to 69.5% of nanodevices., the average annual increase in market nanotechnics by 16% (Glazuev, 2010).

The greatest growth will be characterized for nanoelectronics - 35%, nanobiomeditsiny - 56%, consumer goods - 46% Energy - 13% of controls and environmental protection - 1.5%. The global market for nanorobots and nanoelectromechanical devices will grow from 40 million to $ 830 million at an average annual growth of 83% (Global market for nanotechnology slated for high growth through 2013).

Nano biotechnology sector is currently the most attractive to venture capital and investment is in the amount of more than half of all funds. Biotechnology is one of the most high-tech industries in the world, the research component of which is the main part of the investment. Thus, in the USA in 2006, just presented at the public market biotech companies have invested in R $ 27 billion is estimated that biotechnology raised more than $ 25 billion for investment financing in 2007 and raised more than $ 100 billion c for the period 2003 to 2007 (Investments in biotechnology: undue risk or bet on the favorite?).

In the foreseeable future is expected to increase in areas of advanced nanotechnology. According to the European Commission, 2015, will require about 2 million workers to the global nanotechnology industry. Leaders in the number of people employed in the field of nanotechnology called the USA, Japan, the European Union (Hullmann, 2006).

Among regional markets leadership remains with the USA, where most nanotech companies in the world. USA Leadership is not only achieved leading positions in the growth of the previous one. The most important condition is to finance development of its key factors. USA is the absolute leader in terms of both public and private spending to finance research and development activities and investment in the development of nanotechnology. Funding for development of various nano-budgeted 63% of leading U.S. corporations included in the list of Dow Jones Industrial Average.

In advanced countries, the driving force behind the development of nanotechnology has been the state. In the USA implemented a federal program called the "National Nanotechnology Initiative", with an annual budget of more than $ 1.0 billion and involving 23 government agencies (Glazyev, 2010).

As the aging conditions and the formation of relevant markets is becoming increasingly important business activity of the private sector. Currently, the funding of nanotechnology in the USA, Europe and Asia, corporate contributions to the financing of nanotechnology is growing. Already in 2005 the amount of corporate funding of nanotechnology in the USA and Japan, exceeded the amount of public funding, reflecting the transition phase of growth of nanospheres.

According to US NanoBusiness Alliance, now begins the active redistribution of the nanotechnology market. It is predicted that the USA will take 30% of the market for nanotechnology, Japan - 25% EU - 20% with a predominant contribution of Germany, Britain and France. The rest will be distributed among China, Russia, South Korea, Canada and Australia. Thus, USA and Japan are projected to retain its leading market position while reducing it to share in Western Europe, Asia-Pacific region, and several others.

According to estimates, the market will occupy most of the nanomaterials and nanoelectronics. RAND Corporation were isolated areas of nanotechnology revolution. The greatest chance of success are: USA, EU, South Korea, Japan, Australia and Israel.

In the RAND study assessed the prospects of Russia the most skeptical. It is expected that China and India will make a step toward rapprochement with the leaders. Russia also faces abutting the group less technologically advanced countries - Brazil, Chile, Mexico and Turkey. Indicated that without an active research policy in our country will be hard to compete not only with Japan, USA, a number of other highly developed countries, but also actively reinforcing its sector research and development activities by China and India. From the perspective of RAND, China, India, Poland and Russia are inferior leaders, as weaker drivers of nanotechnology development in these countries, combined with relatively high barriers along the way. In this situation our country is opposed to the situation in China, where, along with a skilled labor force growing number of researchers.

While projections suggest keeping the leading countries of their leading position in the long ascent of a new wave, more and more obvious that leaders of the rival is China. We know how much attention is paid to China's preparation of highly qualified specialists in the best universities in USA and Canada. Chinese citizens among the foreign leaders, receiving a Ph.D. from USA. The emphasis is on training in the first Chinese experts on the technical and natural sciences. Since 1997, China implemented the National Programme the most important basic research, designed to provide the scientific basis for future development, release it to the advanced technological frontiers. The plans to turn China into a major scientific power decisive step must be done in the next 15 years. During this period, are planned to reduce dependence on foreign companies to achieve this level of innovation development of strategic high technology, which guarantees the national security of China, will provide a strong position in the global scientific and economic competition. The implementation of these plans is based on the strong financial support from the central government and provincial administrations. In general expenditure on research and development activities is expected that over the decades, China will overtake USA.

Taking into account the purchasing power parity of national currencies of China, government spending on nanotechnology are already in second place in the world, edging out Japan and Germany. Rapidly growing and corporate expenses for these purposes.

Conducted in China nanotechnology research directed at solving energy and environmental problems. China pursues a mixed strategy for economic development. In industries catching up the task of better use of the competitive advantages of China's low labor costs. However, with access to advanced scientific frontiers of the conditions for the strategy of scientific and technological leadership. To implement these strategies, taken appropriate measures of industrial policy. With the support of central agencies 103 companies have become experimental centers of innovation, pulling over the others. Over the next five years, the number of pilot enterprises will increase about 50 times (Rey, 2004).

The results show that the rate of development of nanotechnology in the leading countries in nanotechnology exceed the growth rate of gross domestic product, reaching in some areas 30-50% growth per year. In countries such as USA, Japan, European Union, where the pace of development of nanotechnology are particularly high, an increasing share of the funding for development of nano-making business. And in the USA today, the share of the business exceeds the share of public financing and funding of these processes from the budgets of individual states. High rates of application of nanotechnology in the private sector in many sectors of the economy leading the world testify to the introduction of a new technological system in the recovery phase.

In Russia, despite the achievements and developments in nanotechnology, there is a significant gap between the quality of the research, science and technology created by backlogs and poor infrastructure of nanotechnology in the country, slow commercialization of existing developments. Weak susceptibility to the development of industry in the area of nanotechnology and the primitive strategy for financial institutions in the transition of the world economy on an innovative path of development are the main constraints. Favorable commodity price backdrop is not used for the development of nanotechnology, which promises a significant competitive advantage to those countries where the strategy for the innovative development is actively supported by government and business.

Development in the Russian sphere of nanomaterials and nanotechnology, development progress, there may be, we believe in the unity of Industry, Science and state, the priority of basic research and commercialization of applied research and technical developments in the field of nanotechnology.

**Effect of nanospheres on the trajectory and pace of economic development**

The source of the generation of scientific knowledge for the production of nanotechnology and nanomaterials in Russia are the academic and educational institutions established for the most part in the pre-reform days, the state corporation "RUSNANO" and dozens of companies organized to develop and promote project developments in this area with the participation of public and private capital.

During that time, while Russia made the first attempts to move to nanospheres, there were significant changes in the scientific and technological potential of the country. Decreased significantly and qualitatively changed the

system of research institutes and design bureaus greatly reduced. The number of specialist technical and engineering occupations declined from 1.94 million in 1990 to 793 thousand in 2008 (Ministry of Education and Science of the Russian Federation, 2009). The costs of research and development activities were also reduced, and 1.14 per cent of gross domestic product. Most of the work, about 61% financed by the public sector, private sector accounts for 29%, on foreign sources of capital of 9% (RUSNANO, 2008). Strengths and weaknesses of research and innovation in economic practice is partly reflected in the development of nanotechnology. Judging by the number of published scientific papers by Russian scientists, local theoretical research in the field of nanotechnology are at the very beginning of his career, but they are quite rightly regarded as competitive . On the prospects of this area can get an idea by examining only a few parameters in table 1.

Clearly shows that public expenditure in nanotechnology in 2008 exceeded one billion dollars. According to this parameter Russia ranked third after the USA and in Japan, the number of patents - the sixteenth place (0.2% of the number of patents in the field).

Table 1: The cost of the development of nanotechnology in Russia (billion rubles)

| Types of Cost | Fact | | Plan | | Forecast |
|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012-2015 |
| Research and development | 8.2 | 9.8 | 11.2 | 13.1 | 25.7 |
| Infrastructure | 10.9 | 9.1 | 9 | 2 | - |
| Expenses "Rosnano" | 20.3 | 21 | 22.8 | 19.5 | 80.5 |
| Private investors | - | - | 6.5 | 7 | 40 |
| Other expenses | 0.1 | 0.3 | 0.4 | 0.6 | - |
| Total | 39.5 | 40.2 | 49.8 | 42.2 | 146.2 |

Source: RUSNANO (2008). Innovative development – the basis of modernization of Russian economy.The national report. Retrieved from http://www.allventure.ru/articles/27/#replies_page

The most spectacular project investment nanotechnology industry is a private business company, "NT-MDT," which specializes in the design and manufacture of microscopes with a scanning probe and other equipment necessary for research in nanotechnology. The company owns 10 percent of the world market such microscopes, and 90 percent of the market in Russia and CIS. In 2007, the income of the company "HT-MDT" amounted to about $ 65 million. It has a wide network of foreign suppliers and affiliates in the Netherlands and Ireland. "HT-MDT" invests about 20% of revenue in research and development activities and maintains active cooperation with foreign research laboratories and organizations (RUSNANO, 2008).

The company "Optogan" develops and manufactures high-brightness light-emitting diodes, whose development has significantly improve the efficiency of LED lighting and greatly reduce its cost. The company has research offices in Finland and pilot production facilities in Germany. State Corporation "RUSNANO" together with the investment fund ONEXIM Group plans to invest in a project to develop the production of LEDs by 2013 6.0 billion rubles.

So attractive this project is doing what in the lighting of humanity is now entering a new phase, moving gradually to light manufacturing technologies based on semiconductor nano-heterostructures that the consumption of electricity is about seven times more cost-effective, and the duration of their work over 25 times higher than that of conventional incandescent lamps.

This market is developing very fast: about 25% per year in the whole world, and 66% a year - in Russia. As an indicator of the relative cost (efficiency) of different types and kinds of lamps commonly used value of kilolyumena created light. And if you recently have LEDs, this figure ranged from 20 to 40 dollars per kilolyumen, it is already "Optogan" offers LEDs for $ 10. Current cost of compact fluorescent lamps - about $ 5.

The strategy of interaction between science, business and government to accelerate the transition from laboratory to industrial nanomaterials technologies, interesting design innovations, developed with the direct participation "RUSNANO" experts named: Super-coating, manufactured by promylenno "Prepreg - SCM" on the basis of carbon and nanomodified mineral fibers to cover the aluminum tubes. The design of "RUSNANO" offer some very interesting technology solutions for use in road construction modifier pavements developed on the basis of a new composite material.

The relatively rapid development of scientific and technological capacity in the field of nanotechnology and nanomaterials has provided grounds for optimistic forecasts of production of the products up to about a trillion rubles in 2015. Such an achievement would mean for Russia, the growth of the global nanotechnology market share to 3% and a transition from individual nanotechnologies and nanoproducts to create a full-fledged industry.

If, however, despite the crisis in 2015, under the most optimistic estimates, the market will show an example of the growth of $ 3 trillion, Russia's share in this market is hardly close to 1%. As has already achieved to date results on the domestic market of nanoproducts, the experts estimate the total volume of Russian market in 2009 will amount to 81 billion rubles, or about $ 2.7 billion. Assessment of the achievements of the world $ 250 billion. That is, until the Russian market is just over 1% of the world.

In the field of electronics "RUSNANO" encourages the development of electronic technologies that are not based on silicon, above all, a plastic electronics. It is expected that the total global electronics market, which is not based on silicon, will grow from $ 3 billion in 2008 to 28 billion in 2015 to 100 billion in 2020. "RUSNANO" expects to receive in this fast growing market of up to 10% as a strategic partner, the corporation has chosen the number one company in the world in the development and manufacture of plastic components and final electronic products - Plastic Logic, which operates in the U.S. Silicon Valley. Since it has signed an agreement to begin construction of the largest factory in Zelenograd, which will focus on the production of plastic machines of new generation.

Particular attention in the "RUSNANO" paid to the development of solar power projects. Microsoft is actively investigating the prospects of several competing technologies in this field, starting with the crystalline silicon and thin films, and ending with the technology hubs because each of these technologies, according to experts, there is great market potential. Thus, the only segment of the solar PV installations are expected to more than four-fold increase in the global market for the period from 2008 to 2015.

Promising direction of development of nanoscience and nanotechnology industry - biotechnology. For "RUSNANO" is certainly one of the priority areas. At present, the corporation has already set up in this area 13 project companies, and the total investment in projects approved "RUSNANO" is more than 30 billion rubles, including co-financing "RUSNANO" in excess of 13 billion rubles.

Among them, in particular, known for his many publications in the media project "Skulachev's ions". The Corporation can not be embedded in the legendary "tablets from old age", whose development is still at a very early stage, but will invest about 700 million rubles in that part of the project, which by 2014 should reach the commercial level. It is about creating droplets from the diseases of aging eyes.

About 600 million rubles, "RUSNANO" invests in the development of a new method for diagnosis of disorders of blood clotting. Until recently, the world was not sufficiently simple and accurate tests to identify the risk of blood clots that lead to such common diseases as stroke and heart attack. Our scientists have not only been able to develop such a technique, but also to create prototypes. In this design, and great prospects in the Russian and the world market.

In addition, 1.3 billion rubles, the corporation has invested in the creation of GMP-production nanovaccines and therapeutic products based on nanostructures and nearly as many - in the manufacture of equipment for track membranes cascade plasmapheresis, high-tech way to clean the blood. Finally, more than 700 million rubles invested in the production of microsources brachytherapy - treatment of cancer patients with Radiomedications. Radionuclides will be delivered accurately to the target - in cancer cells - in special capsules with no damage to healthy cells.

Another bearing block strategy "RUSNANO" - funding for the production of nano-and thin films (nanostructured materials). The total investment "RUSNANO" together with private partners in this area now stands at more than 26 billion rubles. One of the flagship projects in this area, which allocated 3.5 billion rubles - the creation of the production of new composite materials, prepregs (RUSNANO, 2008).

**Conclusion**

To achieve significant development indicators for Russia nanospheres (production and distribution of nanotechnology and nanomaterials) was created earlier by the scientific and technological potential. Russia has made significant advances in the development of the nanospheres (production and distribution of nanotechnology, nanomaterials, nano, etc.) to the beginning of the XXI century.

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