Introduction: contemporary institutional landscape of nano-science and nano-technologies in Russia

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Nanotechnologies in Russia took the form of a social phenomenon, and as such, they underwent two stages of development and entered in the third. The first stage can be described as "fashion approved by the state". However, since the science in the USSR and modern Russia has been and remains an almost exclusively government area [1] financed from the budget with priorities managed by country's leadership, the public endorsement of a certain research area will take a paramount significance. It is not surprising that the period 2007–2009 was accompanied by a set of all those social phenomena, which usually go with a rapidly emerged fashion: lots of fakes, the emergence of pseudo-gurus, ceremonial public events where participants either did not have any relation to nanotechnology or were distant from it, but those few professionals who found themselves there were deeply embarrassed and disappointed.

The crisis of 2009 had a healthy-and-sobering effect on the main players and regulatory authorities of the process. Money was spent much more meaningfully; more attention was paid to the actual scientific component of promoted achievements in nanotechnology and, perhaps most importantly, there emerged a clear vector to the creation of an existing industry. State Corporation Russian Nanotechnologies 'Rusnano' was transformed into a joint-stock company in which the state remains a major shareholder, but, at least formally, there is opened the possibility to attract private capital to the head investment fund and the main regulator of nanotechnology areas. The Fund for Infrastructure and Educational Programs (FIEP Rusnano) took over the functions of

promoting not only the projects that have received investments from OJSC Rusnano but also independent producers of nanotechnology products and services with the use of nanotechnology. Rusnano team managers began to use a new key indicator for reporting to the leadership of the country and the general public – that is a volume of production of the country nanotechnology industry. For registration and monitoring of this indicator, they had to adjust the process of collecting statistical data, so a separate Rosstat reporting form appeared [3]. One way or another, all kinds of products coming to the attention "of nanotechnology managers" are divided into categories according to the degree of use of nanotechnology and the level of innovation.

All these and other measures aimed at the development of infrastructure and optimisation of 'landscape' for nurturing new industry, as well as investments made in specific industrial projects, have produced their results. During the period 2011–2013, the volume of shipped nanotechnology products grew from 160.7 to 416.1 billion rubles. At the same time, 98 portfolio projects of Rusnano produced goods on 75.1 billion rubles in 2013. For comparison, the volume of investments into these projects in the same 2013 amounted to 294.1 billion rubles (including 134.1 billion rubles from OJSC Rusnano and 160 billion rubles from external co-investors) [4].

Thus, the second stage of the development of nanotechnologies in Russia can be characterised as an increase in production capacity of the nanotechnology industry. Practically, all efforts along the way met with system difficulties associated with a poor institutional environment. So, it is not surprising that large structures and organisations related to the field of nanotechnology have invested many resources in the establishment of a general ecosystem promoting the emergence and introduction of any technological innovation.

There is not just one bottleneck in this way, in fact there are a few potentially limiting constraints. First of all, there is wanted a fundamental scientific knowledge which should accumulate constantly. Virtually all potential left over from Soviet times has been involved in projects of the "first wave of nanotechnology mobilisation". At this, world science progresses very quickly in the first decades of the twenty-first century because the new communications technologies, new opportunities in the big data processing and other factors accelerate the generation of new knowledge on a global scale. Therefore, strategically a critical step on the part of the state was the creation of the Russian Science Foundation (RNF) in 2013; its regulatory framework maximally facilitates access to sources of grant funding for scientists. In 2015 RNF financed more than a thousand projects for a total amount of 14.56 billion rubles [5]. 7.4 million papers based on the results of these research have been published in journals indexed in the Web of Science system.

Commercialisation of research results often begins with the enthusiasm of young researchers, and also represents a potential bottleneck for the widespread adoption of new technologies. In Russia, the support of this link in the innovation chain is the Foundation for Assistance to Small Innovative Enterprises in the Scientific and Technical Sphere [6]. For example, in 2014 the Bortnik Fund issued more than 5000 grants (for a total amount more than 800 million rubles) only on the program 'UMNIK', i.e., for the very first step on the path from research results to commercial product idea [7]. All in all, the Bortnik Fund spent 3.7 billion rubles on the different programs in 2014 [8].

Virtually all the development institutions have certain forms of business programs, such as support programs for start-ups, i.e., for small businesses that already have an innovative product and make the first steps for the introduction of this product into the market. In particular, the FIEP Rusnano reported the creation of 161 start-ups in the field of nanotechnology in 2015 and announced plans to bring this number up to 505 in 2016 [9]. The Russian Venture Company takes significant efforts to develop venture capital market [10].

Finally, a distinguishing feature of the Russian way of formation of a new industry based on nanotechnology is to use the lobbying capacity of the major financial groups. Thus, some Russian regions, territorial entities of the RF, have included in their regulations a provision on the mandatory share of innovative products in the public procurement conducted through the regional order. For example, in Moscow, this situation warrants the purchase of not less than 5% of innovative products, which in 2013 was 52.5 billion rubles in absolute terms [11]. Similar provisions have already been taken or are planned to be adopted in the majority of state corporations. It is evident that this way of "a compulsion to innovate" has a lot of rough edges, but in general, these measures will contribute to the formation of positive expectations of the business community about the demand for innovative products in general and for products using nanotechnology in particular. A policy of import substitution in the Russian industry, which was adopted in response to the economic sanctions by some Western countries, has become an additional factor, which stimulates the formation of demand for original Russian developments.

In this context, VII Conference of Nanotechnological Society of Russia (NSR) has been held. NSR is a Russian public (non-profit, non-governmental) organisation, bringing together more than 1000 members who are private individuals. The organisation was created on the wave of 'fashion' and then has undergone a series of major changes: primarily in the form of a rotation of activists, a departure of outsiders and, on the other hand, determining the forms of regular collaboration with those who connect their career with atomically precise technologies. Therefore, NSR can be considered as a kind of an informal indicator of both the state of institutions that have an influence on the development of nanotechnology and attitudes and expectations placed on nanotechnology in society.

Conference proceedings overwhelmingly focused on the scientific aspects. Approximately 15% of the statements could be roughly related to the field of fundamental research, these are works devoted to the study of the properties of nanoscale structures, effects of electromagnetic radiation interacting with such structures, a mathematical modelling and prediction of new properties of matter during the various processes at the atomic level of structuring.

The largest number of proceedings, approximately 60%, was focused on applied research, the experience in the development and practical application of those or other technologies. The main thematic areas were:

- creation of bulk nanomaterials and their industrial technology (polymer composite materials, nano-structured metals and alloys, ceramics, glass, undoped crystals, hydro- and aerogels and so on)
- application and research of nanoscale properties of coatings and thin films (anti-corrosion, anti-friction, wear-resistant thin film as part of heterostructures)

- microelectronics (development of a new element base, the creation of integrated micro- and nanoelectronic devices using nanoscale effects)
- biomedical nanotechnology (technology of targeted drug delivery, biocompatible and biodegradable medical equipment, laser technology in medicine, comprehensive treatment using nano-modified products)
- instrumentation and new techniques for nanotechnology research (equipment and methods of scanning probe microscopy, electron microscopy and spectroscopy, X-ray diffractometry, metrological methodology and standards).

About 20% of proceedings were focused on topics related to the social aspects such as education, public perception of the risks and threats posed by new technologies, attempts to outline a profound philosophical understanding of the processes occurring in human society in connection with the widespread introduction of nanotechnology in everyday life.

Finally, approximately 5% of the conference reports were devoted to organisational matters, methodological studies and the review of historical retrospective.

Thus, considering the status and prospects of the development of nanotechnologies in Russia regarding formal and public institutions we can imagine a classic curve with a steep rise, a sharp decline, and access to a level plateau, exceeding the original. Now, we are witnessing the beginning of a third phase, which we can designate as a phase of consolidation of positive forces, both on the part of relevant government agencies and from professional non-governmental non-commercial organisations.

References and Notes

1 In 2013, budgetary expenditure on research and development in Russian Federation was 88% of gross domestic expenditure on R&D [2]. The total amount of USD 24 billion is far behind the most developed countries (30th place in the World), due to the relatively low level of private investments.

2 Ezhegodnyi monitoring sredstv vydelennykh iz federalnogo budjeta na finannsirovanie NIOKR. Analiticheskiy otchet pravitelstva RF. (2014) [Analytical report of RF Government 'Annual monitoring of federal budgetary expenditure on R&D', December, 2014] http://ac.gov.ru/files/attachment/4879.pdf (in Russian).

3 Ob utverzhdenii statisticheskogo instrumentariya dlya organizacii statisticheskogo nablyudeniya za deyatelnostyu predpriyatij i organizacij v sfere nanotekhnologij. Prikaz Rosstata Rossii ot 13.12.2011 #496 (1-NANO Svedeniya ob otgruzke rabot i uslug svyazannyh s nanotekhnologiyami) (2011) [Russian Federal State Statistics Service Order of 13.12.2011 # 496 'On approval of statistical tools for the organization of statistical monitoring of the activity of enterprises and agencies in the field of nanotechnologies' (1-NANO 'Information about shipping, works, and services related to nanotechnology')] (in Russian).

4 Svinarenko, A.G. and Dalin, V.V. (2015) Nanoindustriya Rossii. Statisticheskij spravochnik 2011–2014. FIOP. 2015 [Nanoindustry of Russia. Statistical Manual 2011–2014] (In Russian).

5 Rossiyskiy Nauchniy Fond. Informaciya o deyatelnosti v 2015 godu (2015) [The Russian Science Foundation. Information on the Activities in 2015] http://рнф.рф/sites/default/files/буклет-2015.pdf (in Russian).

6 Federal State Institution 'Foundation for Assistance to Small Innovative Enterprises in Science and Technology'. Popularly, this organisation is still called 'Bortnik Fund' on behalf of the main initiator of its creation Ivan Bortnik. In 2007, I.M. Bortnik stops to manage the Fund's operations, taking up the post of Chairman of the Supervisory Board. In 2016, A.G. Swinarenko, CEO of FIEP RUSNANO, replaced him in this position.

7 The Member of Youth Research and Innovation Competition ('UMNIK') provides grant funding which generally is available to individuals aged under 35 years for the implementation of the initial stages of research and development in order to prepare the result of research to commercialisation.

8 Godovoj otchet Fonda Sodeystnia Raznitiyu Malykh Form Predpriyatiy V Nauchno-Technicheskoy Sphere [Annual Report of the Foundation for Assistance to Small Innovative Enterprises in Science and Technology], http://www.fasie.ru/upload/docs/Annual_Report%202014.pdf (in Russian).

9 Press-reliz 'Itogi Nablyudatelnogo soveta Fonda infrastrukturnyh i obrazovatelnyh program' [Press release 'The results of the Supervisory Board of Fund for Infrastructure and Educational Programs'], 18.02.2016, http://www.rusnano.com/about/press-centre/news/20160218-fiop-itogi-nablyudatelnogo-soveta (in Russian).

10 Godovoj otchet OAO 'Rossijskaya venchurnaya kompaniya' za 2015 god [Annual Report of OJSC 'Russian Venture Company' in 2015] http://www.rusventure.ru/ru/programm/analytics/docs/Report_RVC_2015.pdf (in Russian).

11 Moskwa innovatsionnaya, 2014 [Innovative Moscow – 2014], http://investmoscow.ru/media/300949/Презентация-Центра-инновационного-развития-Москвы.pdf (in Russian).