FONDATION SAINT-CYR

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Analysis of the risks and potential interest associated with nanotechnologies in the field of defense and security

June 2012

CHORUS No.: 1050094152

Directorate for Strategic Affairs
French Ministry of Defense

Délégation aux Affaires Stratégiques

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[1] *Nanotechnology in Latia America*, Luiciano Kay, 2006.

ARMIR
Association pour le rayonnement, les mesures et l'imagerie rapide

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Acknowledgments

This study was funded, in part, by the French Ministry of Defense (Directorate General of International Relations and Strategiy).

This study was conducted through analysis of multiple documents and sources of information, but also through fruitful discussions with many scientists in the field of nanotechnology.

We had the opportunity to visit the French Atomic Energy Commission (CEA) facility in Grenoble, France, and talk for two days with many scientists who were kind enough to present their work. We thank them very much, as well as Jean Therme, Pascale Berruyer, Bruno Frémillon Million and their teams who organized these visits. We also thank Jean-Philippe Bourgoin, nanotechnology expert, Laurent Cruzet, expert in high power simulation computing, and Philippe Aubert for their help on all covered topics and for the fruitful discussions we had.

CEA Saclay facility, which kindly let us use IT assets to identify the volumes of nanotechnology patents filed in the countries studied, also needs to be thanked.

I. Scope of study

This study, requested by the French Ministry of Defense (Directorate General for International Relations and Strategy underdirectarate for Defence Policy and Prospective), is designed to assess where nanotechnologies R&D and industrial players are headed with respect to defense and security, in France and other countries. It is based on available data and publications, and on interviews with scientists. The report also attempts to provide a forecast.

Nanoscience's and nanotechnologies cover the design and manufacture of devices and hardware systems in the nanometer (nm) scale. They involve multidisciplinary scientific fields, including physics and biology. They have the potential for breakthrough innovations, which would provide economy or military advantage to countries which master them.

Several countries have launched research and development initiatives in nanotechnologies. Few among them are able to cover all subjects. Collaborations are therefore often required between laboratories in different countries. France contributes significantly to advances in this area, but has difficulty to capitalize on such research. Identifying potential partners for French laboratories is therefore essential. It is also important to identify defense-related strategic issues over which France does not have control, but for which finding partners is difficult, for various reasons.

In addition to France, 12 countries were studied: USA, India, Indonesia, Israel, Japan, Russia, UK, Taiwan, Brazil, Germany, China and South Korea.

I.1 Multidisciplinary nature of nanotechnology

In recent decades, microtechnologies have taken over modern applications (programmable coffee machines contain more than 10,000 transistors, for example). Nanotechnologies are similar, just to a much smaller scale. At a billionth of a meter, a nanometer is 50,000 times smaller than the thickness of a hair! Such dimensions are close to the size of an atom (0.1 nm).

Similar systems (thin protective films, for example) have been manufactured for a long time. A new development, in the past two decades, has been the ability to manipulate and design simple, or even complex, nanometer-sized objects. Nanotechnologies are characterized by their multidisciplinary nature. Indeed, they require chemistry, physics, biology and engineering to work together. For example, biomaterials need skills in nanomaterials and life sciences. Intelligent nanomaterials are based both on nanomaterials and information technologies (sensors). Smart drugs require skills in life sciences, information technology and nanomaterials.

Nanotechnologies interface with multiple other technologies. They may be challenging, but they are also a source of new technical developments.

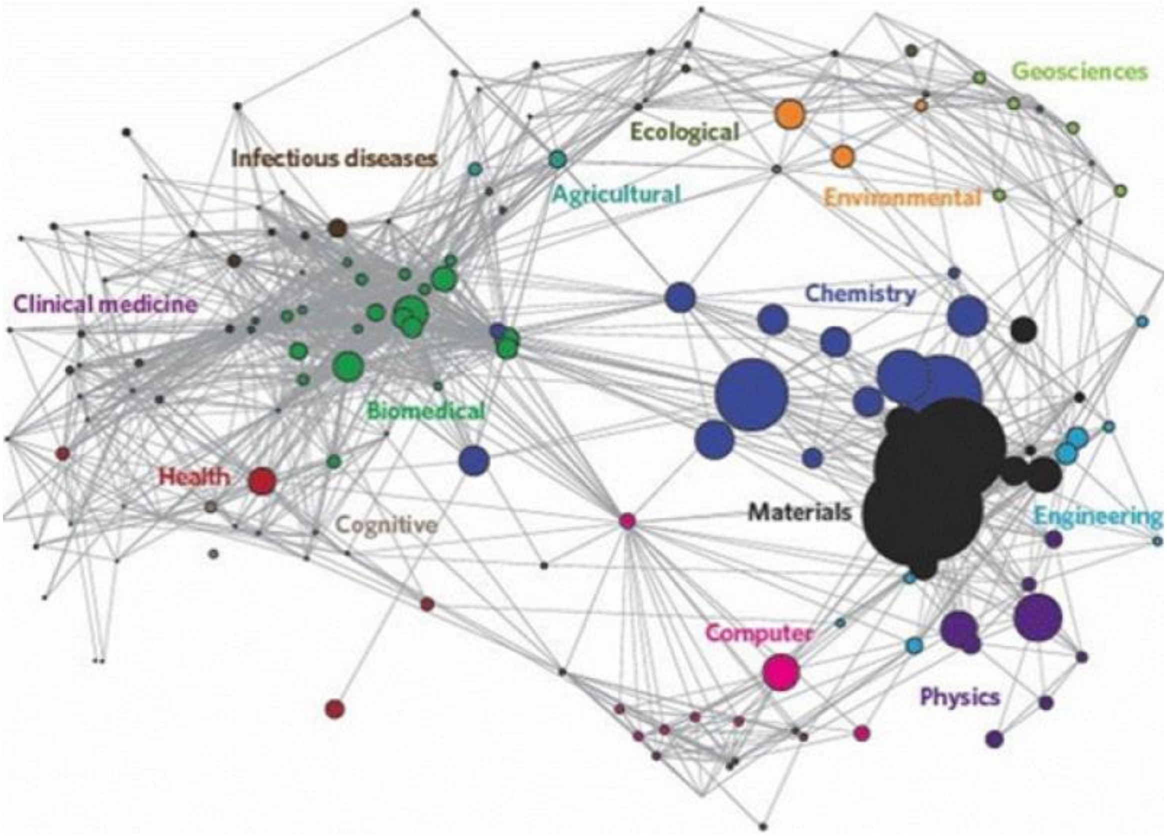

Figure 1. Interaction zone between materials and other knowledge areas. The larger the circle, the more interaction there is.

Source: Rice University, USA; 2009.

Enthusiasm for nanotechnology arises from new features they give to materials. The smaller an object is, the bigger its outer surface is with respect to its volume. Nanoscale objects are characterized by an identical number of atoms in their surfaces compared to the number of atoms with respect to volume. Surface phenomena thus play a predominant role. At the atom scale, conventional physics is superseded by quantum physics. For example, Van der Waals forces (cohesive strength of matter) predominate over gravity (since the mass of nanoparticles is extremely low, gravity barely applies). Therefore, nanoparticles properties are different from those of their macroscopic equivalents, such as for example:

- higher melting point[2] ;
- better conductivity (depending on graphite sheet winding angle, a nanotube is either an excellent conductor of electricity, or a semiconductor);
- greater mechanical resistance (a carbon nanotube is 100 times stronger and 6 times lighter than steel).

[2]Heating a solid agitates the molecules it is made up of. When agitation is sufficient, Van Der Waals forces that keep the solid together break down. molecules remain in contact but become separated. Regular arrangement in space disappears. Melting switches a solid to liquid state.

Two technological approaches are possible to fabricate nano-systems:

- the first is the **top-down approach**; it involves cutting, carving or engraving a material (such as a silicon wafer) to generate nano-sized objects, such as integrated circuits produced by lithography[3]) ;
- the second is the **bottom-up approach,** whereby nano-sized objects or systems are assembled one atom after another, such as dendrimer synthesis[4].

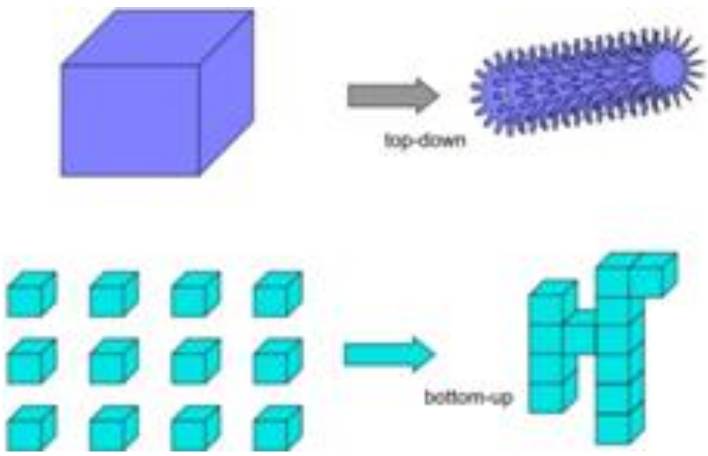

Figure 2. "top-down" and "bottom-up" approaches.

[3] Lithography is a method whereby an image is printed on a flat surface; it is used in electronics.

[4] Such nanoscopic sized macromolecules are characterized by a 3D structure; they are related to hyperbranched polymers, in which branched monomers are associated according to a tree process around a multivalent central core. They generally have a globular shape. In addition, solubility of such macromolecules is greater than analogous linear polymers.

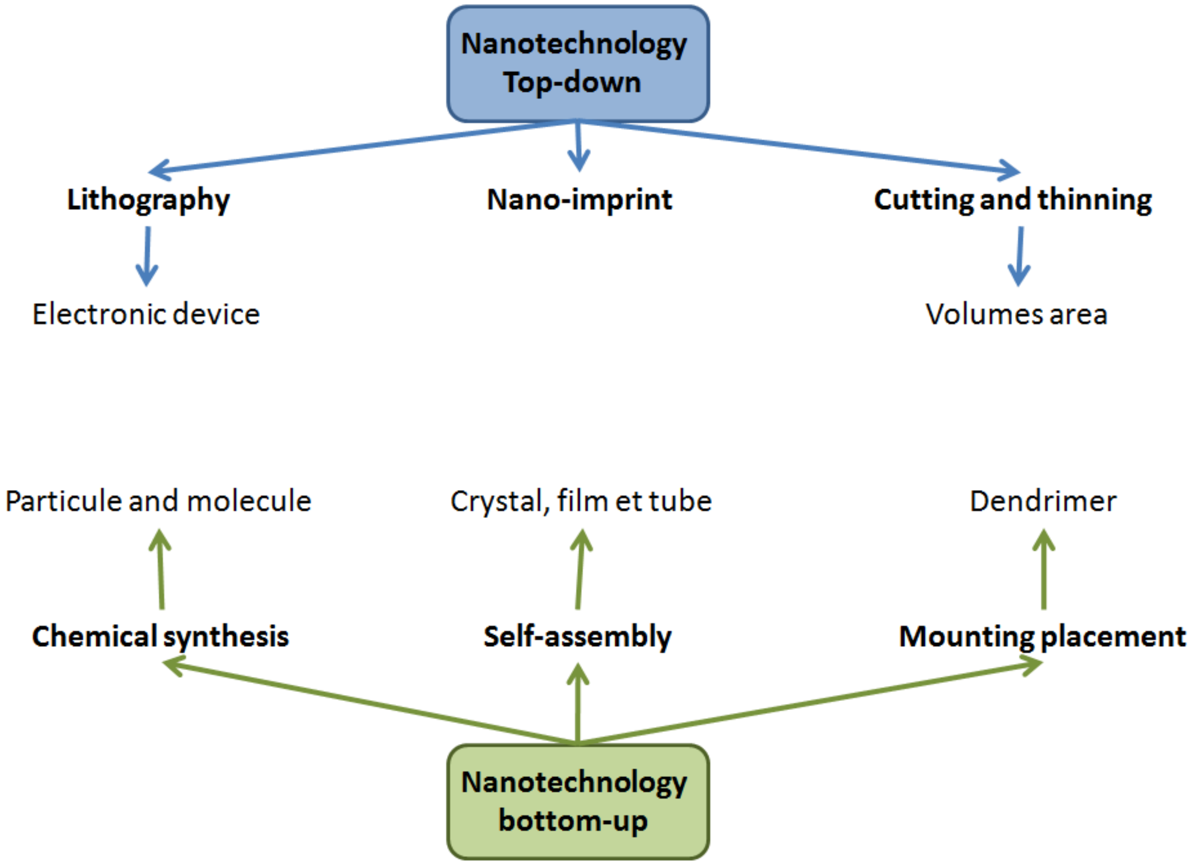

Figure 3. Difference between "top-down" and "bottom-up" approaches.

Study of the Nano world includes:

• **nanoscience**, which study composition of the matter, its properties and how is assembled at the nanoscale;

• **nanotechnologies**, which cover the techniques and tools used to study matter new properties and to develop new devices, objects and systems based on those properties.

For many applications, nanoparticles with specific properties are included in a matrix, thereby creating a functional composite material. Although there may have been, at a time, a craze on the potential applications of nanotechnology, many of the currently marketed applications are restricted to a first generation of nanomaterials. These include:

- titanium dioxide nanoparticles, which are used in sunscreens, cosmetics and some food products;
- iron nanoparticles, used in food packaging;
- zinc oxide nanoparticles, used in outside coatings, paints, and furniture varnishes;
- cerium oxide nanoparticles, used as a fuel catalyst[5].

In 2007, there were 500 consumer products based on nanotechnology, mainly in the field of health and sports, followed by electronics and information technology.

[5]Brasil investe no nanomundo, *O Globo*, 3 March 2011.

Nanotechnologies have a tremendous application potential, and are a wonderful laboratory for understanding the world at the nanoscale. But, to make their application worthwhile, they need to provide a significant advantage over existing technologies, either from the economy or from the technology point of view. Thus, to replace a micro device, a Nano device needs to provide one of the following benefits:

- new features;
- cost reduction while by providing the same functions;
- significant performance increases at the same cost, or slightly higher.

Since many nanotechnologies may have both civilian and military applications, both areas are closely related, and thus have a dual character. The use of civilian technologies in defense can reduce costs, and may also reduce system obsolescence through state-of-the-art devices or systems. Defense also has a trickle-down effect on the civilian field, albeit to a lesser extent than it used to. However, it has the advantage, compared to the civilian field, of being able to plan for the future by funding research which, while having no immediate applications, may be of strategic interest for the long-term.

I.2 Health risks

Although nanotechnologies have advantages, they also may create risks to those who manufacture or use them. There are different types of risks:

- Most systems made up of nanomaterials do not pose a particular risk to users in normal use. However, a risk may appear at the manufacturing level, if nanoparticles are not entirely confined to prevent operators from contacting them. Also, during deployment of nanostructured materials, at the end of their use or during decommissioning operations, there is also a risk of nanoparticle dispersion. In defense matters, there may also be a risk when use of nanoparticles cause them to disperse, such as when using ammunition which generates them.
- certain applications use nanoparticles and additives to prevent caking, such as in certain foods, or sun tanning products containing TiO_2 nanoparticles. Long term safety guarantee is not fully established, especially after long periods of exposure.

I.3. Nanotechnology promises for defense and security[6]

In addition to the many possible civilian applications, nanotechnologies may have defense and security applications. Like in the civilian field, four areas have a large potential for applications: energy Nano sources, nanomaterials, Nano electronics and Nano sensors.

New threats

Nanotechnology can be a source of new threats from countries or terrorist groups. These threats may be chemical, biological, radiological (dispersion of radioactive products), nuclear, or based on difficult to detect explosives.

Vectorization nanotechnology[7] and Nano encapsulation[8] are being developed by the pharmaceutical industry for making drugs and image contrast agents, and by the cosmetics industry. **Unfortunately, in the context of non-conventional weapons, technologies developed to improve the administration of drugs can be used for the delivery of biological or chemical agents.** Nanotechnologies might thus help the militarization of biological agents, toxins or chemicals, as follows:

- By preventing their fast degradation by air, sun or heat in the environment;
- By making it possible for such toxic agents to cross natural barriers preventing entry into the body (blood-brain barrier or blood-tissue barrier, e.g.);
- By transporting and targeting toxic agents to specific cells or organs, thereby reducing the doses necessary to achieve lethality, thus providing for new carriers such as water and food;
- By facilitating release or activation of biological agents in desired amount at the desired time;
- By making agents undetectable and unidentifiable (by masking the sites recognized by detection tools).

Many of these options would eliminate operational difficulties encountered during the production of such weapons, and could therefore make them easier to use. Moreover, production of nanomaterials has increased significantly in recent years, and large quantities of these are now available on the market. Meanwhile, prices of these materials have been falling.

[6]Chapters 11 and 13 are drawn from the study: "Outlook in Strategic partnerships between France and Brazil in nanotechnologies" Ariane Castel, Chlorodia Company, May 2013.

[7] Those act as a carrier for a bioactive molecule, which is attached to, or incorporated into, nanomaterials (certain polymers, carbon nanotubes, inorganic nanoparticles, etc.). Such materials can bind to receptors and enter into cells. This greatly improves the efficiency of the bioactive molecule.

[8] A bioactive molecule is contained within a capsule. This technique provides stability to an unstable bioactive molecule, allowing it to be transported, as well as timed and controlled release.

Nanotechnologies therefore make up a new threat requiring regulatory changes, in particular export controls.

New opportunities

Fortunately, nanotechnology can also improve detection and countermeasure devices (detection of nuclear, radiological, biological, chemical and explosive attacks, as well as neutralization of espionage devices). Miniaturization allowed by nano devices enables development of discrete, low-cost and low-power consumption information gathering systems. To allow wide deployment, sensors must be inexpensive. This is where nanotechnologies can make the difference with microtechnologies, since mass production reduces costs while increasing device reliability and portability.

Figure 4 shows relationships between some technologies and some defense and security needs. It shows items with dual applications.

This diagram shows the strong duality of nanotechnologies. For example, metallic nanostructures (nanomaterials) which help making missiles lighter are also useful for vehicles, aircraft or drones.

Moreover, it shows how mastery of a technology such as carbon nanotubes opens up to numerous applications: improved battery performance, miniaturization of antennas and storage memory, increased sensor sensitivity, and many others.

The diagram also shows how some capabilities are at the intersection of various fields of applications (such as batteries and materials); mastering those would impact many areas.

Nanomaterials may also find applications in protection systems, either as reinforcement or armor against projectiles, or as skin providing stealthiness, with some nanostructures.

Nanoelectronics makes production of miniaturized components possible, providing for increased redundancy of electronic system, thus improving reliability.

Portable energy sources are the weak point of most nomadic devices requiring energy. Such power sources must have a large energy density per volume and mass units. Volume and mass do not always go hand in hand. Hydrogen, for example, which is a much talked about energy carrier, has a high energy density per unit mass (33.3 kWh/kg, i.e. about three times that of gasoline) but a low energy density per unit volume (1 kWh/L at 350 bar, i.e. 10 times less than a liter of gasoline). Energy sources must be able to recharge quickly, must be strong, reliable and able to withstand extreme conditions such as temperature, radiation, etc.

Portable power sources include batteries, which can be made with many different technologies. Li-Ion technologies have become predominant, thanks to their good performances. However, 1 kW/hr requires 5 kg of batteries to provide the same energy as 700 grams of gasoline.

Pairing battery technology with a smart "power management system" based on miniaturized electronic components is important to increase battery performance, durability and reliability for specific missions. Supercapacitors, a complementary technology, also can provide power while having a practically infinite number of duty cycle compared to batteries.

A number of technologies provide for recovery of unavoidable energy, such as ambient heat, vibration during movement, light, etc. Such technologies, although still emerging at the industrial level, should develop in the coming decades. A case in point is thermoelectricity, which requires nano-engineering to achieve interesting performance for low-cost applications.

Nano catalysis is a strategic process area, providing a strong economic benefit through lower costs and improved ease and efficiency of chemical reactions; it can even make some chemical reactions industrially feasible.

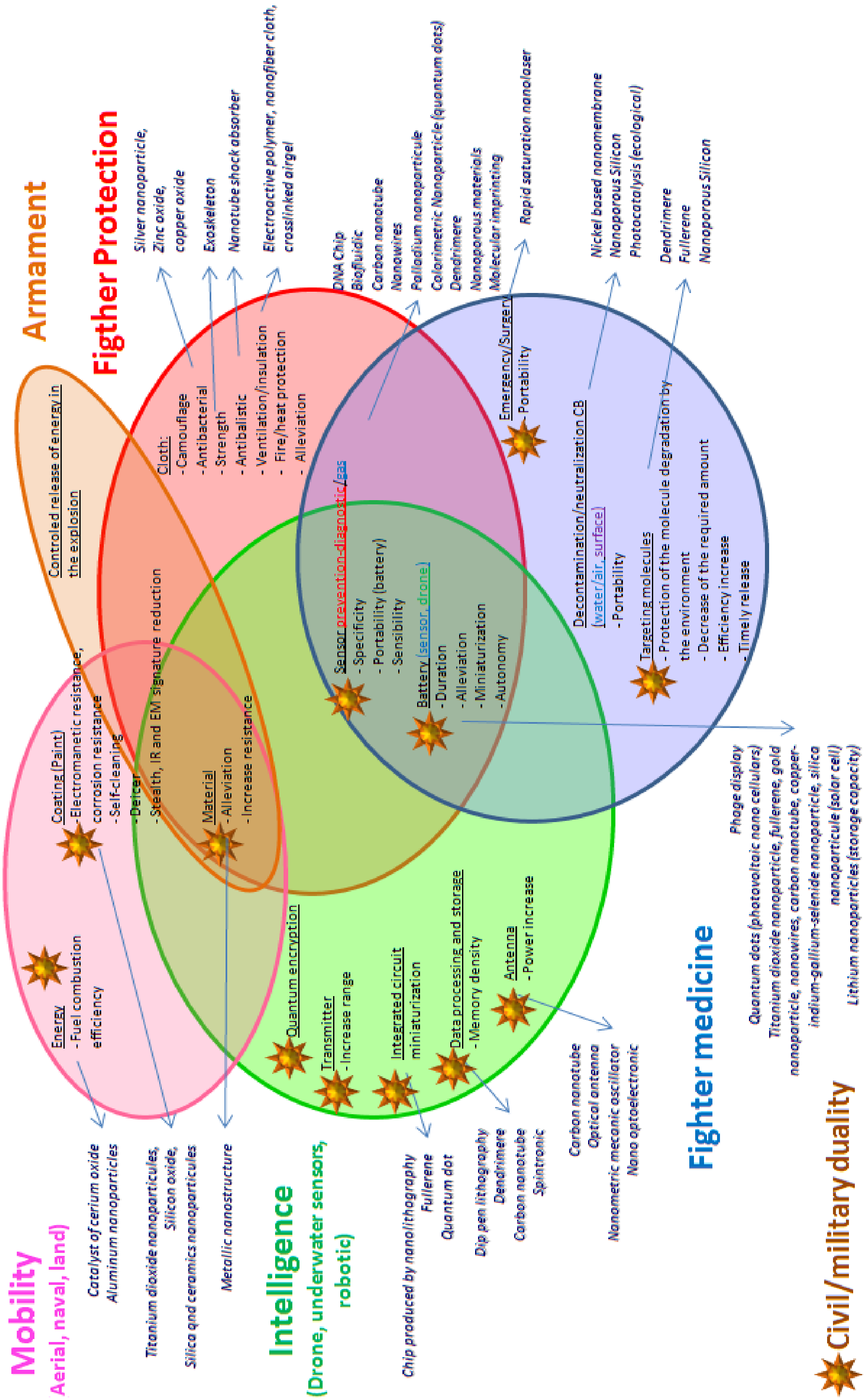

Figure 4. Overview of some technologies with dual applications for defense and security.
(Source: Société Chlorodia.)

II. Regulatory framework

This section contains an outlook of the current legal framework which can, to some extent, impact France's industrial and defense capacities, penalizing its industries, particularly in terms of nanotechnology exports and imports.

II.1 Preamble

Current scientific research practices require researchers to publish and apply their discoveries quickly, which inevitably leads to dissemination of information and development of products before any potential restrictions for security purpose may be imposed.

In the nineteenth century, Pasteur replaced the "principle of foresight," which was based on the notion of good or bad luck associated with an individual, by the prevention principle, based on scientific estimates of the spread of diseases in human groups. This prevention principle itself was replaced, in the twenty-first century, by the precautionary principle when Society took notice of uncertainties inherent to understanding of our world, scientific as it might be. Said precautionary principle, now part of the French Constitution, now causes over-control, as it tends to be applied to anything new, including nanotechnology[9]. Although current nanotechnology-related regulations are still minimal, they are expected to grow in the near future.

In addition to the above precautionary principle, itself based on uncertainty about the effects of nanotechnologies, other economic- or defense-related considerations have been added. They involve standards restricting nanotechnology data and products. The potential impact of such growing restrictions on our industrial and defense capacities will be examined.

II.2 Regulatory constraints

As international, European and French laws are constantly changing, three types of motivations leading to nanotechnology-related laws can be identified:

- The primary motivation is **protection of people and the environment** due to the relative ignorance about the danger of some nanomaterials whose effects might be disastrous in the medium or long term. This caused development, as a direct result of the precautionary principle, of a European regulation which has yet to be transposed into French law.

> **France's Executive Order 2012-232**
>
> Because of unfamiliarity regarding danger of certain nanomaterials, the Ministry of Ecology; Sustainable Development, Transport and Housing has taken measures concerning production, distribution and import of substances in the nanoparticulate state (Executive order no 2012-232 of 17 February 2012). This implementation order is the mere transposition into French law of European Regulation 1907/2006 of the European Parliament and of the Council of 18 December 2006. It sets the amount of nanoparticles above which reporting is mandatory at a threshold of 100 g.

9 Thérèse Leroux, *Le Principe de précaution et le questionnement que suscite la nanomédecine*, in Christian Hervé, Michèle S. Jean, Patrick Molinari, Marie Angèle Grimaud, Emmanuelle Laforêt, *La Nano-médecine. Enjeux éthiques, juridiques et normatifs*, Ed. Dalloz, Paris, 2007.

- A second motivation arises from the desire to control production and trade of nanomaterials which can be used **to develop defense**, **attack or protection equipment**, or for **terrorist purposes**, and might lead our partners or our foes to gain an edge over our national capacities, or would even allow non-state groups to develop terrorist capacities.

- The third motivation arises **from the will of some international industrial groups** to keep for themselves any financial benefits provided to them by production and sale of certain nanomaterials, or any derived goods.

Faced with this trend whereby laws keep being expanded, undesirable consequences of implemented regulations should be considered. Indeed, some nanomaterials may prove essential in nano-medicine, in the pharmaceutical industry, for the treatment of certain diseases, or to decrease chemical pollutants. In technological and industrial terms, nanomaterials may also cause major developments in our understanding of the world or the behavior of our societies.

More specifically, we want to avoid some of the negative effects induced by excessive regulation. For example:

- Restrictions **should penalize neither basic university research nor French industries R&D**. In particular, no regulations should cripple the flow of information or the movement of goods required for said research.

- Restrictions **should not cripple French defense industry** by preventing French companies from exporting some products, while preventing them from gaining contracts essential to their survival.

- Controls **should not restrict growth** of French civilian industry through complicated waiver procedures or making them wait longer for government's approval.

Regulations are implemented in three ways:

- Control can be based on lists of goods; such lists can be international, European or French. Such lists, based on descriptions as accurate as possible, of the goods to be restricted, need to be updated continuously, based on technical developments and introduction of new materials.

- Thresholds of material quantities beyond which the control should apply also need to be defined. Such thresholds also need to be adjusted from time to time based on impact studies.

- Finally, a control system for checking proper application of the law needs to be implemented. Such regulatory agency must possess technical and legal powers to analyze applications made by companies, and grant any required authorization within a reasonable time.

Export and import control of dual-use goods

Control of dual-use goods

Exports and imports of Dual-use goods (DUG) are highly supervised by law.

DUG are goods which, based on an international definition, are subject to restrictions and export control because they could be used for design and manufacture of conventional weapons or weapons of mass destruction.

Such lists are made up by international agencies, such as:

NSG (Nuclear Suppliers Group) for nuclear weapons, MTCR (Missile Technology Control Group), AG (Australian Group) for chemical and biological weapons and Wassenaar Agreement (WA) for conventional weapons.

Said four lists are concatenated at the EU level; they have been published in European Regulation No. 388/2012 of 19 April 2012.

DUG export control lists are continuously revised and updated to account for advances in technology.

Development of nanotechnology is impacted significantly by such control lists. Indeed, almost all of the ten categories of goods in Regulation 388/2012 use nanotechnology, in particular categories 1 (Materials, Chemicals, "Microorganisms" and "Toxins"), 2 (Materials treatment), 3 (Electronics) and 6 (Sensor and Lasers).

Taking electronics, which includes photolithography chip manufacturing, as an example, it appears that France controls export of measuring and chip manufacturing tools, as well as export of some raw materials. However, some of our foreign partners have implemented the same export controls, which may have a direct impact on some of our imports.

Because of such updates to the lists of controlled goods, French government, as well as our companies, need to take an active part in related international and/or European bodies to defend our legal and technical interests.

Evolution of monitoring strategies for control lists

Experience has shown that three types of strategies may emerge within international bodies.

- A first strategy aims to reinforce non-proliferation policies, and to fill gaps of in lists by adding items, and / or, if necessary, widening technical parameters of already-listed goods.
- A second strategy, on the contrary, aims at preserving industry and trade, and promotes easing of controls.
- A third type of strategy reduces controls of obsolete technologies and strengthens controls on technologies one is the only to master.

It is notable that countries attitudes evolve according to their threat perception and evaluation of their foreign trade.

Current trend within the Wassenaar Arrangement (WA), is to move towards a general easing of control, as demonstrated by the number of “non-control” proposals (about three quarters of all proposals.)

However, it should be underlined that there are currently comparatively very little discussions about nanotechnology within the WA.

Discussions about nanotechnologies are currently almost non-existent within NSG and MTCR. In contrast, the Australia Group pays a close interest for the emergence of these technologies.

For example, proposals toward regulating nano-fiber manufacturing machines are currently being discussed.

Note: China is a member of NSG, and is seeking to be involved neither in the Wassenaar Arrangement nor in other arrangements. India, on the other hand, is trying to be admitted in the four export control systems.

There does not appear to be any current desire within the European Commission to question DUG laws, which apply directly as such in each EU State. However there are still some anomalies[10].

Some progress has been implemented within the EU, such as temporary export licenses to take part in trade exhibitions.

Other international regulatory bodies

Biological Weapons Convention (BWC) and Chemical Weapons Convention (CWC) are two international treaties that may be concerned by nanotechnology regulations. Both Conventions have very structures.

CWC has a verification body (OPCW), while BWC has none. However, OPCW, which was created to apply the Convention on Prohibition of Chemical Weapons (CWC) may only, within the scope of its mandate, verify destruction of existing chemical weapons. It may therefore neither concern itself with nanotechnologies nor their possible use in defense applications.

Although BWC could deal with nanotechnologies, it has no verification system. In addition, defining nanotechnology applications with respect to biology raises many problems

Should, for example, nanomaterials be defined based on their size (smaller than 100 nm), which would include organisms like the smallest viruses, or should they be limited to inert materials?

Potential applications of nanotechnologies to biology are numerous, including for defense[11].

[10]The EU Treaty requires that each member countries apply BDU export controls, while some member countries are not involved in certain schemes.

When it comes to the law, the speed of developments in nanotechnologies, which can be measured in months, is hardly consistent with passing bills, which may require years of legal arguments.

This is why, with respect to nano-medicine, some legal experts recommend, according to the Declaration of Helsinki, implementing recommendations and a code of good practice, i.e. a "soft law", which would be less binding and much more flexible. Such an approach may have disadvantages, but would prove in practice better for this new situation.

II.3 Monopolies and patents

Monopolistic approach by some of our foreign partners, French patents application procedures, and the rather passive attitude of French companies, France might quickly lose all benefits from the money spent on research and development which allows French businesses to innovate, develop, manufacture, transform and export in the field of nanotechnologies.

- **Increasing monopoly by some countries**

The past years have seen emergence of a quasi-monopoly on some Chinese electronic components or raw materials.

Specifically, that country now controls over 40% of the worldwide production of microprocessors.

- **Insufficient number of patents filed in France:**

Low number of patents filed in France is partly due to the complexity and diversity of patent legislation in different European countries.

Although a European patent application procedure was put implemented in Brussels, this procedure does not replace national procedures; patent applications still need to be filed in each European country in which one wishes to be protected. France has also the particularity that a patent applicant cannot go directly to Brussel. This explains the difficulty to know whether a patents has been filed in France by a French citizen or by a foreigner.

These drawbacks come in addition to a number of weaknesses in European and French regulations, as well as France's own export control structure, which can have a negative impact on France's export capacity in this field.

Conclusion

In general, existing regulations imposes a number of restrictions over research and development of nanotechnologies; international restrictions are currently few, but are expected to grow in coming years.

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[11] Their use for scattering or disseminating biological agents, for example, or targeting specific areas of the body, may be mentioned.

Defining a long-term national strategy for developing certain branches, together with public funding to be approved by all government agencies applicable, seems to be the essential factor to promote nanotechnology growth.

Such national strategy will have to face raw material and component monopolistic situations, a small number of patents filed, obsolescence of those products being banned due to constant changes in law and a growing technology gap with some partners ; all these factors have a damaging effect on the industry.

II. International situation and the place of Europe

Many countries are now investing in nanotechnologies because they believe the technology may become a source of wealth and employment in the future. The field is growing irreversibly all over the world. Any country not following this move will quickly become outdated and dependent on other countries, with the risk of not being able to access a number of technologies, or able to access them only in a degraded mode. Such a situation may prove to be particularly damaging in the fields of defense and security.

Dependency on foreign countries may cause use restrictions, and therefore restrict actions as well as slowing down or prevent required modification.

Nanotechnologies are an emerging, albeit strategic, in which all countries must find their place based on resources and capabilities; this is why knowing how various countries fare on the global level is important.

Discrepancy between industrial developments and research efforts is not specific to France.

The following Figure shows that, while the EU produces 33% of world publications in the field of nanotechnology, it contributes only 15% of final products, i.e. those bought by consumers. Europe is very good in terms of publications in basic research, but not when it comes to marketing its ideas.

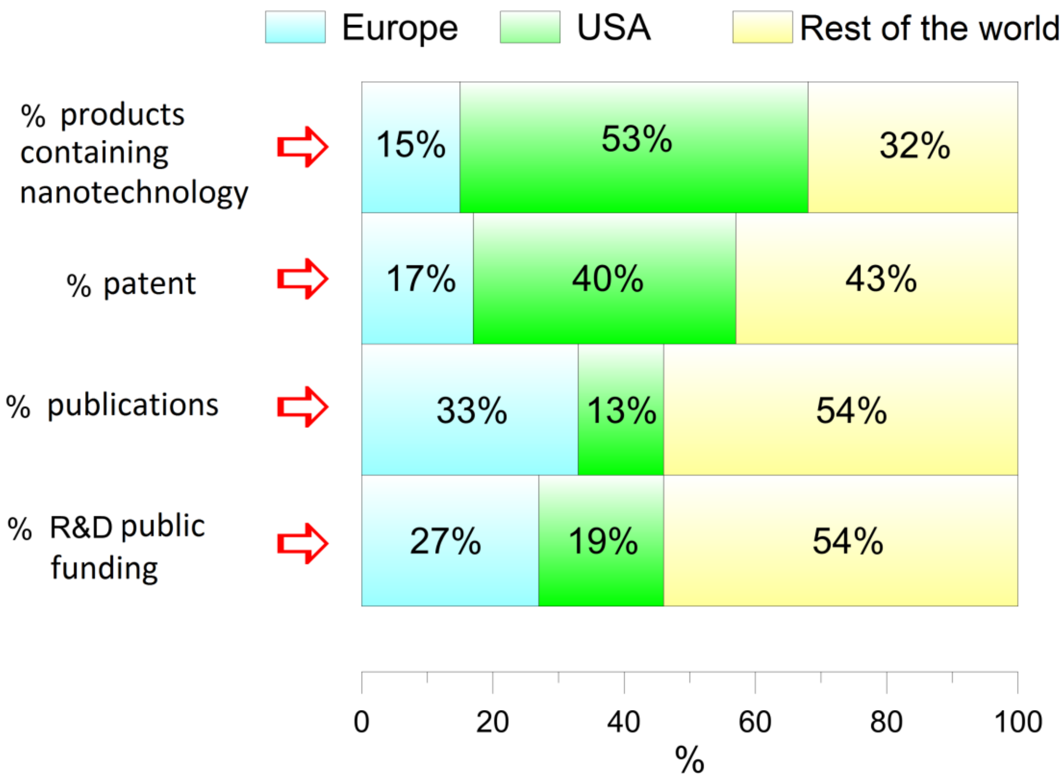

Figure 5. Public funding of nanotechnologies in Europe, USA and the rest of the World.
Source: Figure 8 of "High-level Expert Group on key Enabling Technologies." report

The main target of most countries outside of Europe is to recoup their basic research costs through products and applications.

However, Asian countries are those which most use public funds for their R&D for development, as shown in Figure 6 which compares the USA, China and South Korea. While 48% of US R&D funds are devoted to applied research and 28% to development, China spends 32% and 58% respectively, and South Korea 32% and 44%.

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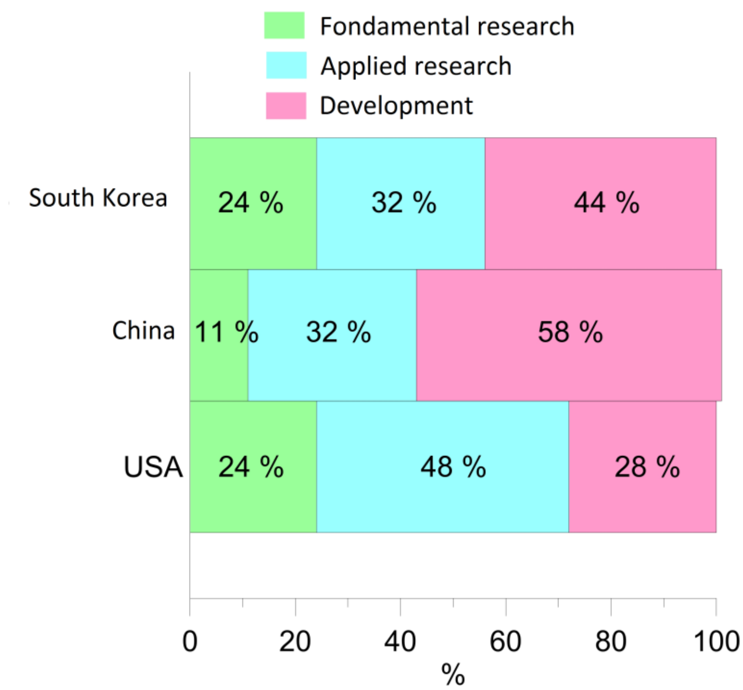

Figure 6. Percentage of funds allocated to nanotechnologies.
Source: Key Science and Engineering Indicators, National Science Board, 2010 Digest, NSF, http://erawatch.jrc.ec.europa.eu/, OECD La France

III. Analysis of some countries

IV.1 Goal and Methodology

For all 13 countries (including France) considered in this study, we have attempted to identify scientific and technological skills, as well as industrial capacities in various sectors, where nanotechnologies are present and would help to meet French needs with respect to military and security applications.

The selected methodology covers several parameters related to the capacity and resources of countries on this issue:

- Identification of nanotechnology initiatives Identification of programs and amount of their financing. Identification of specific military programs.
- Number of government-controlled research agencies;Number of publications;
- Number of patents filed;
- Number of companies, as well as how significant they are in the nanotechnologies field;
- amount of venture capital, if any.

Sources used

Data collection has mainly relied on the following four sources:

- **Identification of the numbers of patents filed in nanotechnologies for the studied countries:**

To assess the scientific and technical level in all nanotechnology-related fields for the studied countries, our research was based on the number of patents filed between 2000 and 2011[12]. Relevance and comprehensiveness of the results depend upon the search terms selected, which can focus on various criteria.

Due to the vast number of concepts covered, it was decided to focus the search on:

- words beginning with "nano" in the title or the abstract; classification codes B82B, B82Y and H01F-41/30 of the International Patent Classification, codes which cover the following categories: "Nanotechnology" and "Equipment or processes for applying nanoscale structures";
- classification code 977 (main class and additives) of the US classification of nanotechnology patents.

- **Systematic use of Nanowerk dedicated database:**

This base offers the advantage of containing worldwide data and to be updated frequently. This USA-based web site, launched in 2005, is mainly funded by subscribing partner companies. However, we believe that these companies make up only a portion of all nanotechnology companies. We have deemed that such partial coverage does not impact business-segment based analysis, especially since an additional list of companies has been incorporated into the analysis process. Furthermore, it does not appear that any bias which would favor specific a business segment has been introduced.

- **Searching for information on the Internet:**

Search was based on identified countries and topics of interests, in order to expand the database above. For example, the "company data rex" web site (similar to France's Infogreffe) has been used for the United Kingdom; the "MATIMOP - The Israeli Industry Center for R & D" web site was used for Israel; the "Made in China" website which references Chinese who want to market these products abroad, has been used for China, etc.

Experts were contacted during the course of the study to obtain additional information on specific countries, in particular France, Germany and Israel.

Data selected

With respect to patents, we have extracted from the abovementioned research, for each country and for each year:

[12] The research was made on the industrial property portal Questel-Orbit server that allows access to nearly all patents filed worldwide, including the countries of interest to us. CEA, which has kindly provided a access right to the server for the research carried out, deserves to be thanked.

1. the number of patent applications based in applicant's country of origin[13];
2. Applications filed with patent offices in the studied countries. Such applications may be filed by in-country organizations[14] and by foreign companies and R&D centers filing in these countries;The ratio of applications filed by in-country organizations.[15]

With respect to companies, overall indexing was done for each country, based on 14 business segments involving a degree of nanotechnologies:

- **(Chemicals) [**photocatalysis, pigments, green chemistry]; **(Basic products)** [nanopowders, nanotubes];**Construction** [building materials (glass, insulation, paints, protection against wear), concrete (curing agent, sealing compound, repair mortar, steel, etc.)];
- **Energy** [power distribution (heat transfer, etc.), energy production (fossil fuels, fuel cells, gas turbines, solar cells, wind turbines, etc.), energy storage (electricity, batteries, ultracapacitors, etc.), energy use (light emissions, etc.)];
- **Environment [**carbon capture, filtration (potable water), sanitation (decontamination, oil spills management, etc.), wastewater treatment];
- **Food** [food wrap (packaging materials, etc.), food processing (filtration, etc.)]
- **Information Technologies and Communication (ITC)** [data storage, electronic display, coatings (lithography, computer chips, heat sinks, ink jet printing, etc.), polymer filters, optics, photonics, semiconductors];
- **Medicine** [therapeutic and antimicrobial agents, dental care (implants), drug delivery, pharmaceutical products (catalysts, etc.)];
- **Precision engineering** [coatings (nanofilms), metrology, optics];
- **Textiles and clothing** [coatings, protection];
- **Transport** [automotive (adhesives, engines, membranes, paint, parts, steel, wear protection, etc.), marine**]**
- **Sensors [diagnosis / R & D** (microfluidic; contrast agents, X-ray probes, etc.), environmental analysis (air, water, etc.);
- **(Services:** consulting, R & D, technology transfer, etc.)

We have considered that **10** (those not between parenthesis in the list) **of the** 14 analyzed segments had **military or security potential application;** they are those which were selected for the analysis.

Among analyzed countries, the USA represents a special case: the vast initial quantity of data (over 1,100 companies) did not allow a full analysis because the budget available for the

[13] All filing procedures taken into account: national, European and global offices
[14] Laboratories & industrialists.
[15] Laboratorie & industrialists.

study could not provide an adapted automatic search engine. Sampling[16] was used to divide the number of examined companies by 10; the hundred or so companies thus selected allowed the USA to be analyzed on the same basis as the other countries.

Usage

With respect to patents, the searches performed show the evolution of patent applications filed for the 13 countries under study, between 2000 and 2011, and provide for easy comparison, in particular in terms of patent applications filed per country and applicant, as shown in the following Figure.

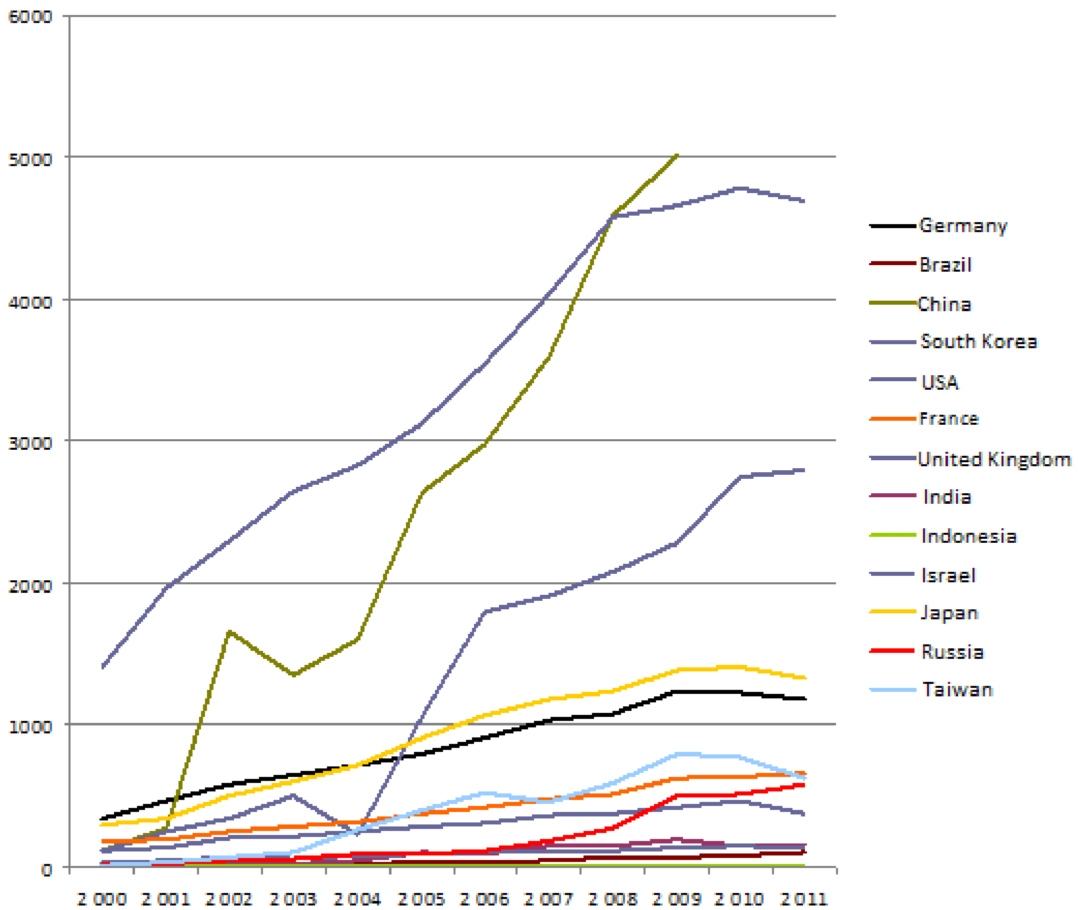

Figure 7. Number of patent applications per country of applicants.

The very strong growth of patent filings in China, which; as early as 2009, exceed those filed in the USA, is a significant milestone[17].

[16] By systematically selecting one company among 10.

Moreover, with respect to paragraphs 2) and 3), relating to applications filed with patent offices, the results of the two filters used are limited to data from national patent offices. These results are no less interesting, freeing the native part of deposits from the foreign one, reflecting to a certain degree, the potential attractiveness of the countries. The evolution of the number of patents going from 2000 to 2011 in all three possible types is shown for each studied country. [18]

A database listing all[19] identified companies analyzed in the study was created.

The first piece of data from this database is the total number of currently-identified companies per country[20]..

Other data covers the number of nanotechnology companies created each year in the past twenty years. This research was done for each studied country, based on company creation dates.

The corresponding chart is included in each[21] country's data sheet.

It shows that company incorporation charts can be split into three categories:

The leading group, composed of:

1. United States (for which only 10% of companies have been sampled);
2. Germany
3. United Kingdom

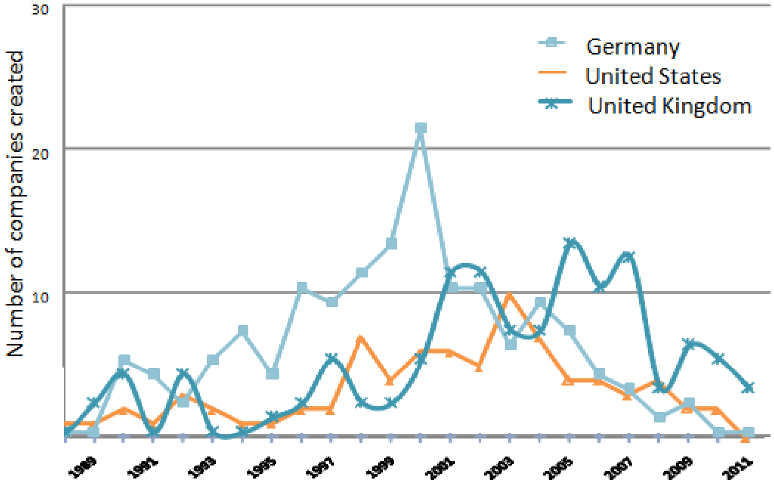

Figure 8. Number of nanotechnology companies created each year by the top group of countries.
Source: Société Chlorodia.

[17] An article from the French Embassy, however, calls for caution, considering that until recently the innovative character of the applications did not always appear sufficiently. Starting in 2010, a procedural reform of national patent filing seems to have taken place to get closer with the practices of other countries.

[18] See the related country profiles.

[19] The means implemented in the study did not make it possible to highlight existence of an industrial fabric in the field of nanotechnology in Brazil and Indonesia.

[20] See the corresponding country files.

[21] .Except Brazil and Indonesia, because no nanotechnology company was identified in these countries.

A second group, made up of countries active in the industry, as follows:

4. Japan
5. France
6. China
7. Israel

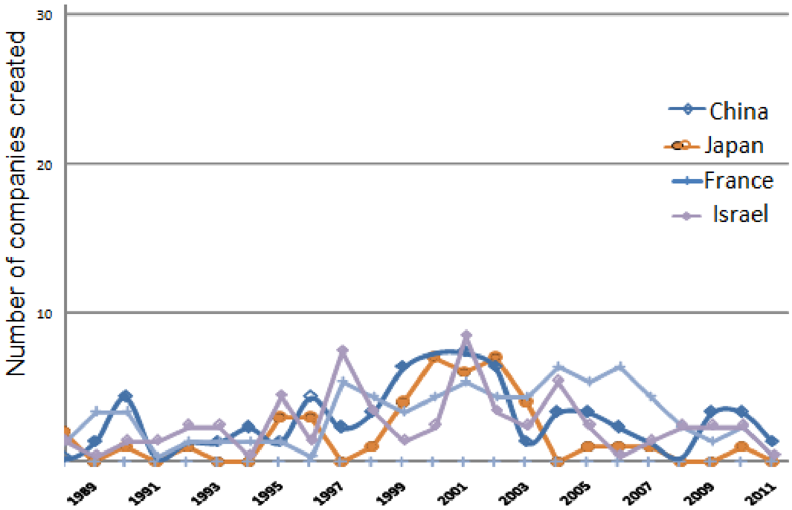

Figure 9. Number of nanotech companies created each year in second-group countries.
Source: Chlorodia

Lastly, a third group comprised of the following countries, each with only a handful of companies:

8. South Korea
9. India
10. Russia
11. Taiwan
12. Brazil
13. Indonesia

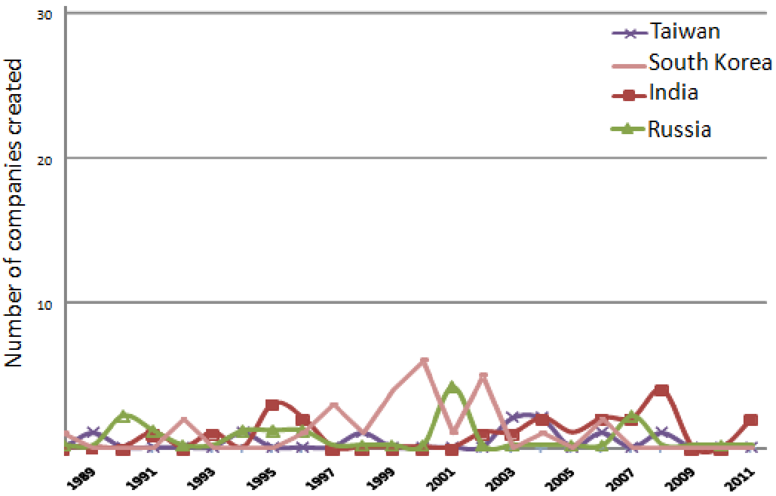

Figure 10. Number of nanotech companies created each year by countries in the last group.

The database also makes it possible to easily see, for a given country, all companies involved in a specific business segment. The number of companies involved in one of the 14 areas listed above has been extracted from this detailed database. This is shown in charts for each of concerned country[22].

Thus, the number of companies involved in a specific nanotechnology field highlights how important this field in the considered country.

[22] See country sections, "Types of companies".

To better quantify this approach, we have analyzed, for each country, the percentage of companies involved in the 10 previously mentioned[23] military or security areas, compared to the total number of identified companies in that country.

The resulting spectrum highlights, for each[24] studied country, percentage peaks for specific business segment. Three percentage ranges categorizing company industrial skills and abilities were then defined, as follows:

- high: 25% and more, Intermediate: between 5 and 25%Low: less than 5%.

[23] The corresponding graphs are shown for each country in this Report.

[24] Russia and Taiwan were not included in this analysis because of the insufficient number of companies found (15 for each country).

IV.2 France

IV.2.a Basic data

Population (2010)	64 millions
Surface area (mainland)	547,000 sq. km
Average population density	112 residents /sq. km
GDP (2011)	USD 2,800 billion
GDP per capita (2011)	USD 43,700 $
HDI (2011)	0.872

IV.2.b France's efforts

France decided, a few years ago, to mobilize significant resources, including dedicated agencies, to develop areas of expertise in nanotechnologies. As early as 1999, the French government set up a National Micro-Nano Technology Network (RMNT) with a view to improving interfacing of government-funded and private research. These efforts have grown over time, and France is beginning to reap returns on this investment.

Sustained efforts

Since 2003, National Network on Nanoscience's and Nanotechnologies (R3N) has been implementing a support plan for a network for large-scale manufacture of nano-structures. R3N's is tasked to finance leading projects through a network of university research labs and partnerships between government-funded laboratories, innovative SMEs and R&D centers of large companies. A major Basic Technological Research (RTB) program, involving CNRS and universities technology centers (RENATECH[25] network) and CEA / LETI, was implemented.

In 2005, National agency for research (ANR) initiated a national nanotechnology program (PNANO), whose implementation is based on R3N. Technological research and innovation networks (RRIT), also supported by ANR, are also involved in micro- and nanotechnologies (RMNT network) and nanomaterials (RNMP network).

France's Ministry of Research currently supports creation of centers of excellence in nanoscience "C'NANO". Currently there are six such centers of excellence, in the following regions: Ile de France - Great East - Rhône Alpes - North West - Great South West - PACA.

The French government has recently retained 67 projects dedicated to micro-nanotechnologies and software technologies that are among the six world-class projects. In France, the major tool promoting commercialization of government-funded research is the Law of July 12, 1999 for innovation and research. This law includes a section dedicated to

[25] www.rtb.cnrs.fr

cooperation between government-funded and industrial research. Said section allows public science institutions (such as CNRS) to create "industrial and commercial activity services" (SAIC) to manage their research contracts and those involving private companies. SAICs may also manage delivery of services to outside customers.

The Law of July 12, 1999 has been amended over the years. As an example, since 2006, the National Research Agency (ANR) may fund research project partnerships between government institutions and private companies. Such funding is targeted in priority to those strategic research areas where private business research effort is considered insufficient (nanotechnologies, for example).

Current funding actions include P2N (financed by ANR), and Nano 2012, initiated in 2008, which combines the R & D centers of IBM, ST-Microelectronics and CEA / LETI. There is also Nano-INNOV, detailed further down. Yearly budgets are €90 million for the P2N program, €20 M for Nano2012 and €20 M for Nano-INNOV. The government also supports development of large infrastructures via Labex (laboratories of excellence) and Equipex (equipment of excellence). During the last decade, France's effort to grow science partnerships was Paris-centric. However, the government has recently become aware of the need to allow greater flexibility to local stakeholders (which is partly reflected in the "competitiveness centers" policy).

Nano-INNOV

Nano-INNOV is an effort to encourage development of nanotechnologies in France. A large-scale investment plan was introduced in 2009 to create centers of technological integration, similar to the Grenoble center involving micro- and nanotechnologies. Development of three such integration centers was started in Grenoble, Toulouse and Saclay. The most recent one, Nano-Innov Paris Region, opened in 2012. This center involves nearly 700 researchers, engineers and technicians. It is dedicated to design and manufacture of innovative systems incorporating both nanotechnology and software.

These three integration centers have their own specialization, as well as transverse activities. In 2005, about 5300 researchers in 243 laboratories were working in the field of nanotechnology. In France, the 4 larger areas involved in nanotechnology are those of Grenoble, Toulouse, Lille and Paris, supplemented by other smaller regional laboratories.

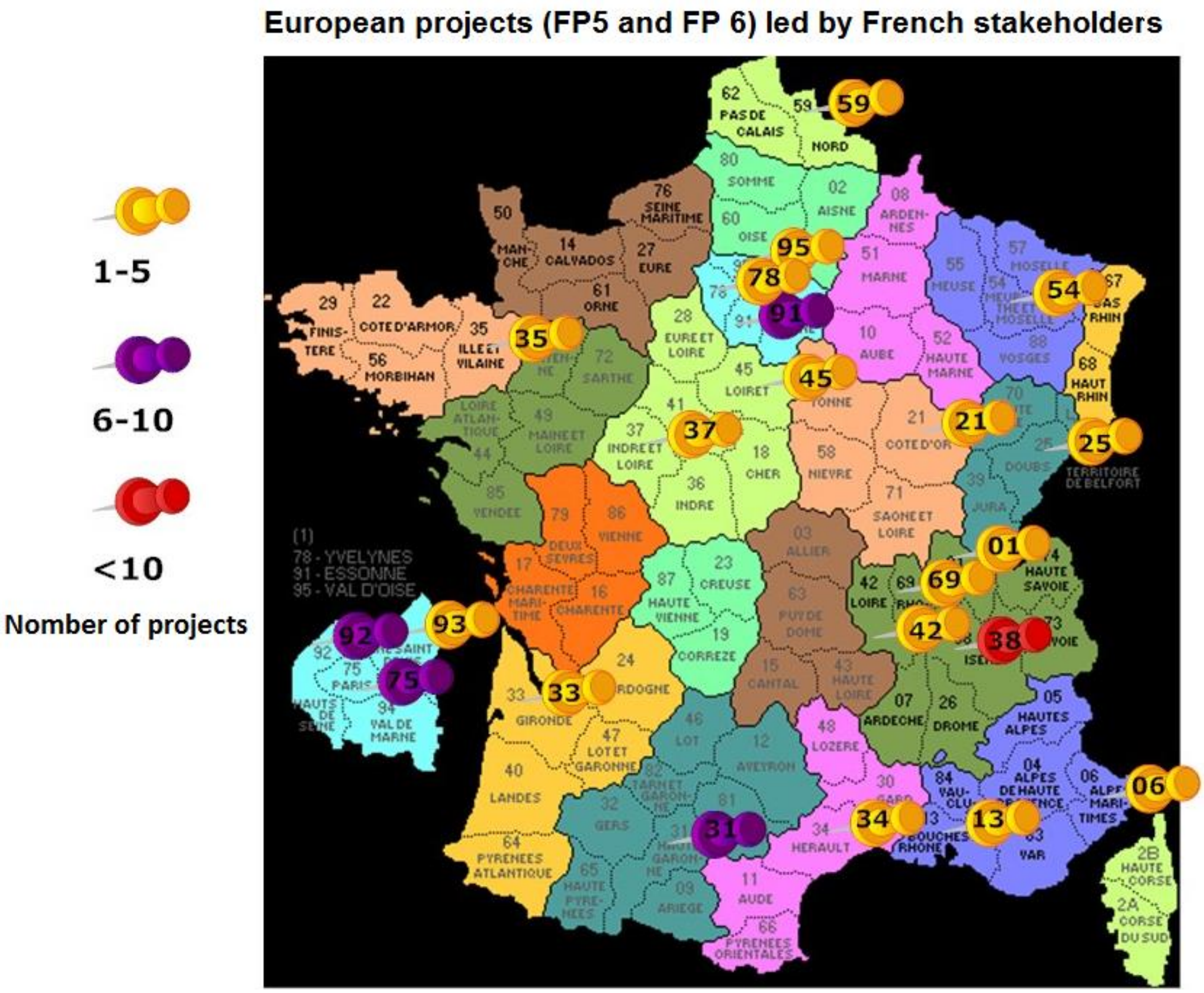

Figure 11. Distribution of French agencies controlling a European nanotechnology project. Black numbers on the pins indicate the department number, pin color shows class and number of projects.

Concentration of activities related to the development of nanotechnologies in France is noticeable. In 2005, there were nearly 2000 scientists in Ile-de-France, nearly 1000 in Rhône-Alpes and Great South-west, and about 500 in Great East, the North West and the PACA regions.

IV.2.c Resources to match goals

The field of nanotechnologies is multidisciplinary, requires large investments and good relationship with manufacturing. Excellence in basic research by itself is not enough; research results must be marketed for revenue and employment to created. France's technological fabric in this area has improved significantly over the past decade and now features laboratories, facilities and tools allowing ambitious goals to be set.

From ad hoc research to collective effort

France has good basic research laboratories, but they are working on scattered topics, and the chain of elements required for research to evolve into a finished product or to obtain lasting industrial sectors is often missing.

For example, even though some of a laboratory research may be able to be manufactured by industry or defense, this is not the lab's primary objective which is to publish research papers and, if possible, to file patents.

It may happen that a manufacturer or the Defense department requests help to solve specific problems from a laboratory known for its expertise. However, there's usually no overall strategy for reaching a goal in an industrial area.

Reaching critical mass

To cover most bases, and to be able to respond to very diverse problems, many basic blocks need to be available so they can be put together to match requirements.

This requires a critical mass of research, as well as dedicated organization to promote development and industrialization, including creating a start-up company if necessary. Collaborative, rather than separate, efforts are therefore necessary for international visibility and efficiency.

A benefit of such an agency would be having very large powers allowing developments that can't be achieved by specialized labs.

As a matter of fact, innovation, by and large, now originates from multidisciplinary research. Example: there are excellent laboratories working on batteries; other labs work on integrated electronics. Combining both skills would allow batteries with optimal performance and life to be made.

The three key areas of nanotechnology are characterization, modeling-simulation and manufacturing. Like a manufacturing critical mass is required to be competitive internationally, critical mass is required for modeling-simulation and characterization,

Manufacturing

We will not delve about manufacturing of nanodevices, nanomaterials, etc., since the government and research contracts with industry have made development of several technology centers in France possible.

Characterization

Even though each laboratory may have their own characterization systems, financial reasons won't allow to do everything. Therefore, large nationwide characterizing laboratories, with the best performing tools, are necessary,. Such devices, with the best possible resolutions and sensitivities, provide for any characterization not feasible by labs own resources. Indeed, the cost of maintenance contracts for such complex devices are too high for small laboratories, and detrimental for their productivity.

Beyond standard characterization means, synchrotron-generated radiation and neutrons are also irreplaceable in some cases for characterization.

France owns the SOLEIL synchrotron, and has access to EU-owned ESRF in Grenoble. SOLEIL covers from far-infrared to X-rays, and ESRF from UV to very hard X-rays. LLB (in Saclay) may be used for neutron generation.

Simulation

For modeling-simulation, the need for a critical mass arises from the ever-growing requirement for intensive computation devices involving thousands of elementary processors. Parallelization of calculation codes has become a specialized job requiring specific facilities with large computing resources.

A specialist is now required to effectively optimize a calculation code on a massively parallel machine with multicore processors and graphic processors.

IV.2.d Publications and patents

A known problem is that France can create knowledge but usually fails to convert such knowledge into wealth. This can be illustrated by comparing the number of scientific publications and patents of France and South Korea (Figure 12).

		Nomber of publications 2006	Nombers of patents 2005
France		3 526	290
Korea		3 162	2 159

Figure 12. Comparison of scientific publication and patent numbers between France and South Korea. From Nano-INNOV report, 2008.

In many scientific fields, France has good quality basic research, but fails to convert research into its potential industrial production. For the 20002010 decade, France's number of patent applications has stagnated in all fields. At the same time, China experienced strong growth and has overtaken France in 2010. The tax credit for research has had a slightly positive impact in the years 2008, especially for SMEs, but with only a small increase on the number of patents filed. France files, on average, three times fewer patent applications than Germany. This correlates with the fact that French industry is about three times smaller than German industry. It is also a symptom of France's gradual deindustrialization.

At a European level, over 60% of patents filed in Europe are the work of non-European countries, as shown in Figure 13. Of the nearly 250,000 patents filed in 2011, 32% were filed by Asian countries. The lower part of the Figure shows the distribution of patent filings by Asian countries (Japan, South Korea and China.)

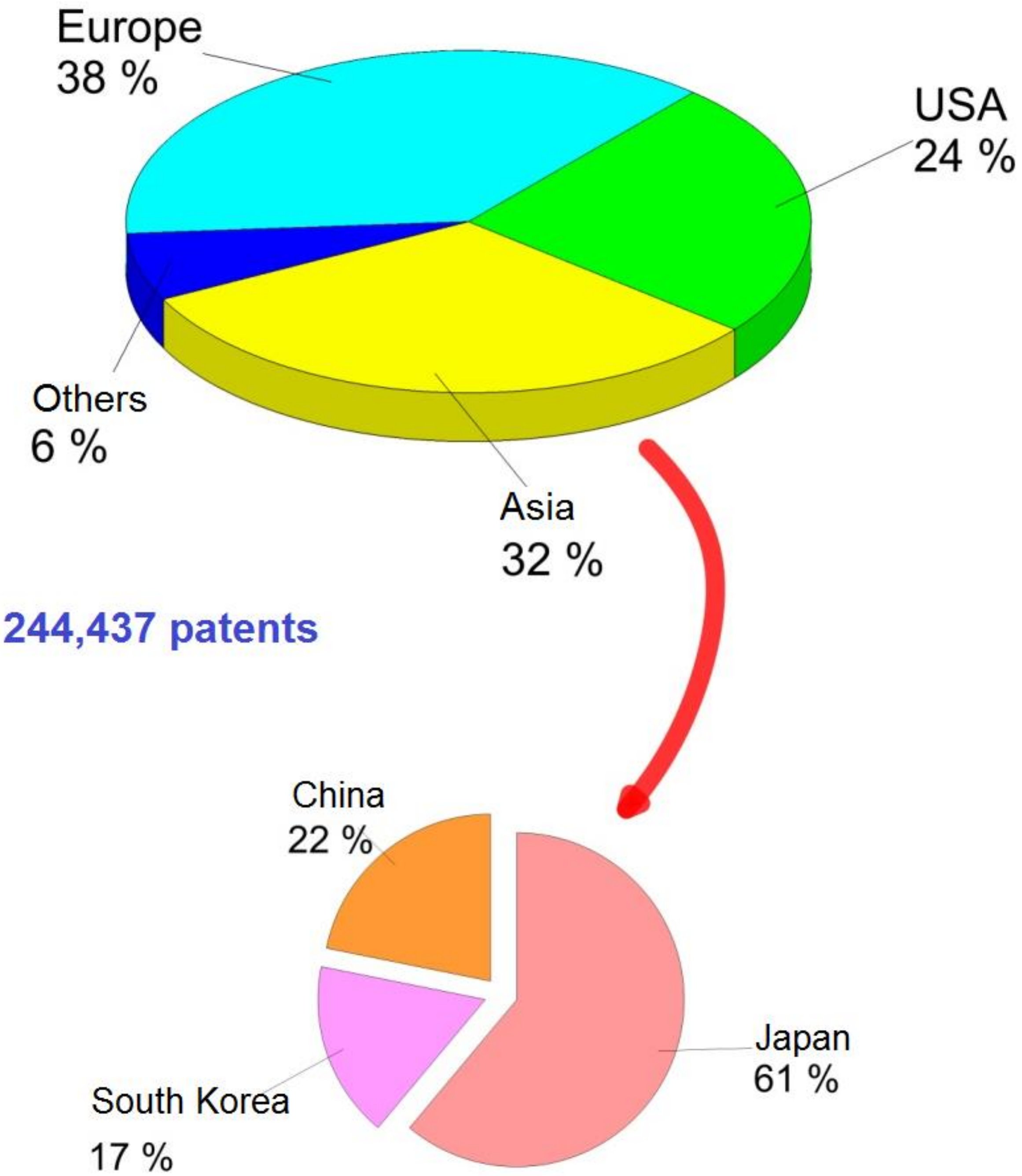

Figure 13. Distribution of patents filed in Europe in 2011.
Source: EPO.

The number of nanotechnology patents filed in France is relatively low, compared to other countries analyzed in this study, and ranks France in 9th position. This number has, however, notably increased between 2000 and 2011 (Figure 14). France stands out from other countries, with fewer patents filed by applicants from other countries.

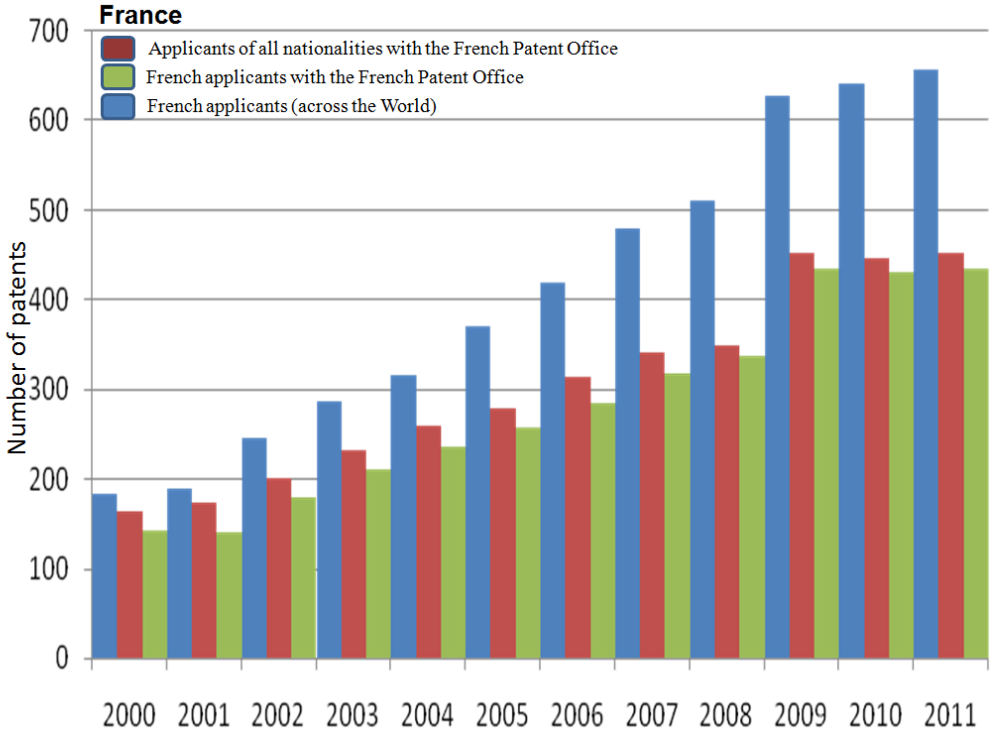

Figure 14. Patents filed in France from 2000 to 2011.

The major issue, not only in France but in the rest of Europe, is not so much the quality of basic research but the inability to create innovation from that research. In addition to regulatory and financial restrictions, psychological factors also keep scientists from converting their research into high value-added products or services, i.e. wealth and jobs.

IV.2.e Types of companies

Creation of French companies implementing nanotechnologies started in 1998. Annual evolution is shown in Figure 15. France is one of the pioneers in the field, behind Germany, USA and Israel.

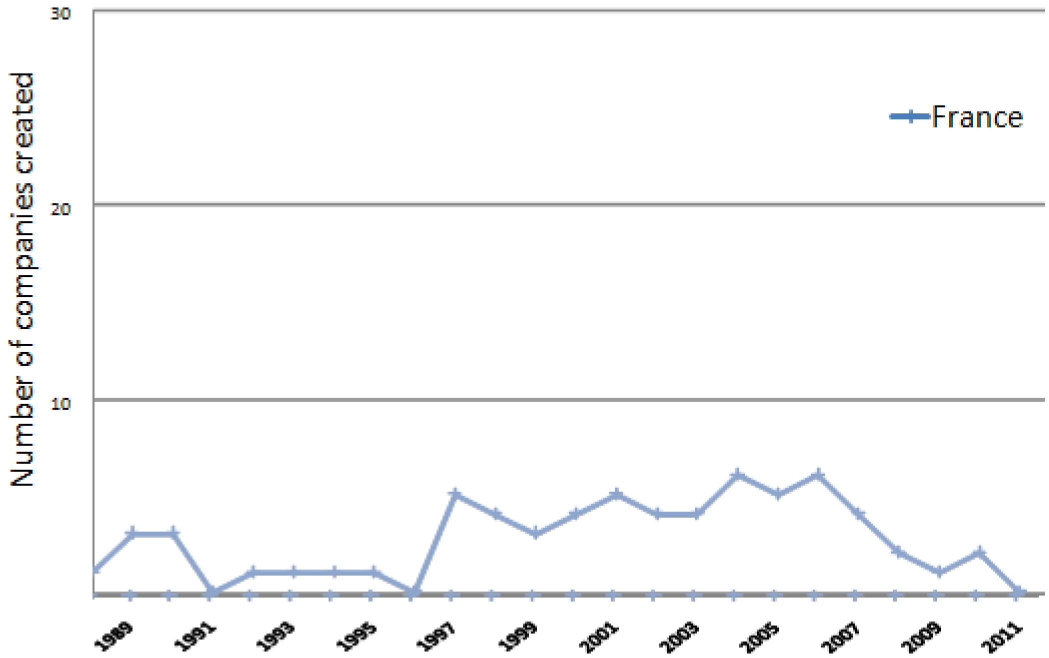

Figure 15. Creation of 66 nanotechnologies companies in France from 1988 to 2011.

The total number of recorded companies is 91, 66 of which having been created between 1988 and 2011.

Unlike other countries analyzed in this study, which for the most part show a peak of business creation around 2001, the number of companies created each year in France remained stable until 2006, then started to decrease in 2007.

The various activity fields of the 91 French companies are listed below (Figures 16 and 17).

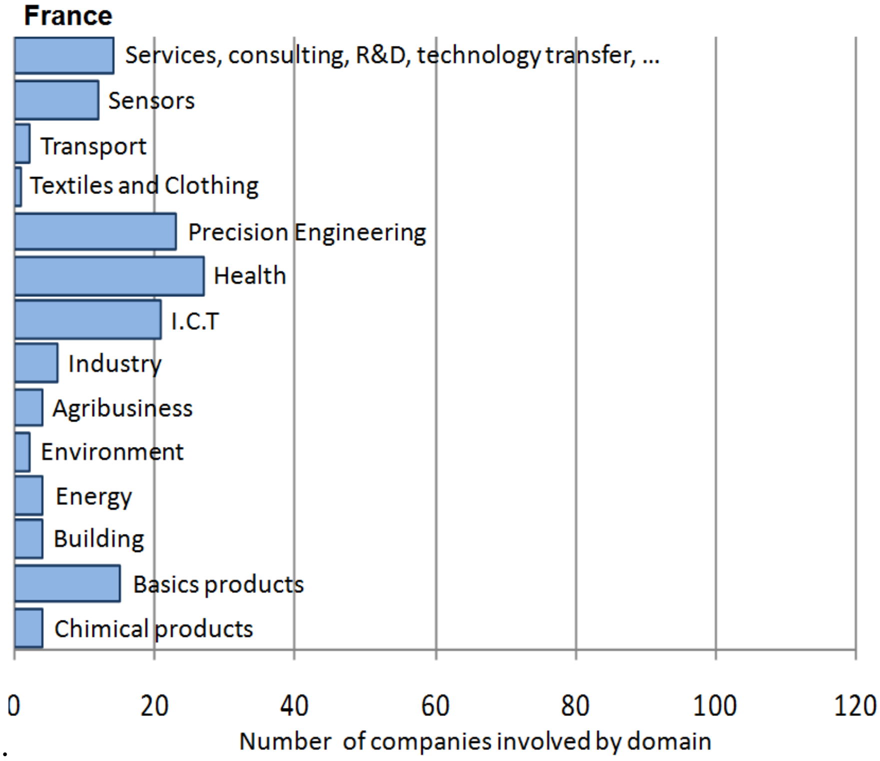

Figure 16. Distribution of the 91 French companies by field.

French nanotechnology companies are especially numerous in the medical, precision engineering and information and communications technology fields. Figure 17 shows the results as a percentage of French companies in the 10 areas identified as potentially related to military and / or security applications.

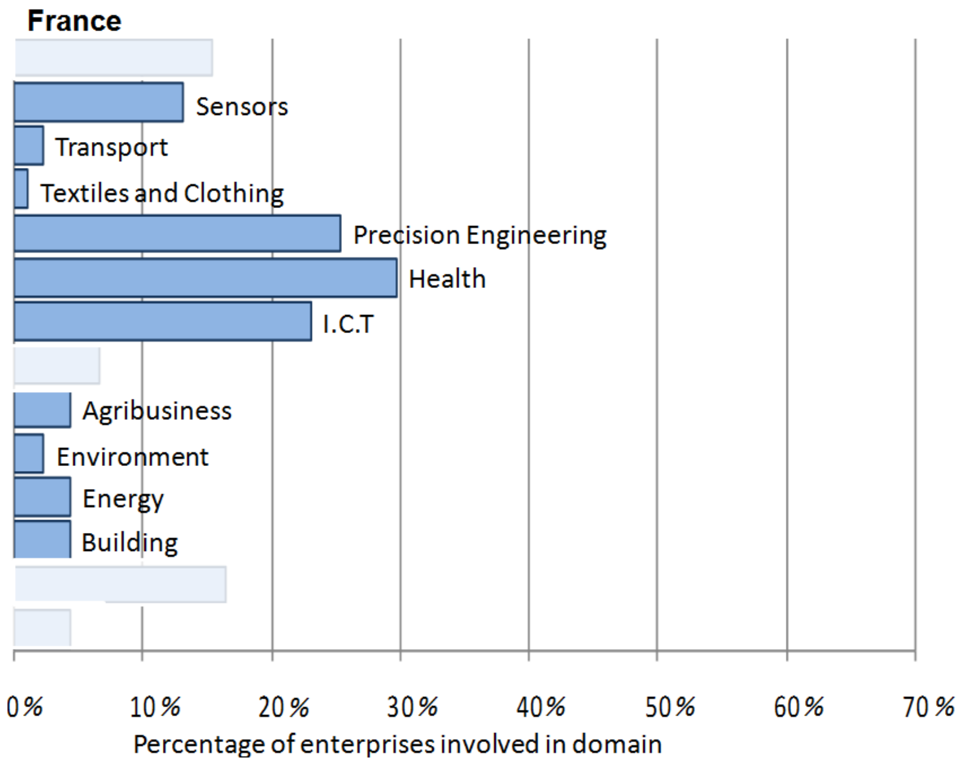

Figure 17. Distribution (percent) of French companies in the 10 selected areas.

Based on these criteria, French companies appear to be strong in the medical and precision engineering fields, whereas they are at an intermediate level with respect to ICT and sensors.

Conclusion

Classification analysis of French companies in the nanotechnology field justify strengthening our national capacities in the Energy field, an issue closely linked to military and security, for which reliance on foreign suppliers and partners is out of the question.

With respect to Textile and Clothing, which are directly related to protection of military and law enforcement personnel, partnerships or acquisitions with foreign countries and/or companies may be considered.

Construction and Transportation, in terms of weight reduction and increased mechanical strength, may be of military interest, and a research for suitable partnerships may therefore be considered.

For fields such as Environment & Food, with little connection to military interests, search for outside supplies is to be preferred, even though the French food industry is extremely competitive worldwide.

ARMIR
Association pour le rayonnement, les mesures et l'imagerie rapide

CHLORODIA

Edmonium

IV.3 GERMANY

IV.3.a Data base

Population (2010)	81 millions
Surface area (mainland)	356,026 sq. km
Average population density	230 residents/sq. km
GDP (2010)	USD 3,900 billion
GDP per capita (2010)	USD 35,900
HDI (2010)	0.885

IV.3.b Germany's efforts

Germany is the leading investor in Europe in the field of nanotechnologies. Since 1998, Germany has developed skills centers, made major investments and built significant facilities, which are available to university as well as non-university research centers. Industry, in particular SMEs/SMIs, benefit directly from these efforts. Organization of research in Germany is structured through public/private partnerships, as well as innovation inside private companies, in order to encourage the development of cooperation between researchers well as development of synergies between existing agencies.

The German Federal Ministry of Education and Research (BMBF) provides significant support to nanotechnologies.

In the 70s, biotechnology and microelectronics were among the priority areas for research and development[26]. One decade later, materials and information technology research were added. In the early 90's, new research in the field of miniaturization and integration of miniaturized components was also conducted. At the same time, efforts in chemistry were also made. They contributed to development of targeted products and to self-organizing principles through combination of individual system components. They contributed to discovery of new design possibilities in the fields of surface technology and materials. The challenge, in the 21st century, is to combine these different disciplines.

Nanotechnologies, together with biotechnologies and information technologies, are considered essential for the next long-term growth cycle. BMBF and VDI Center (Association of German Engineers) have been aware of the long term importance of nanotechnologies, and have supported their development for a long time.

Starting in 1998, BMBF has intensified its support to projects, and has set up the necessary infrastructure through newly-created specialized agencies and skill networks.

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[26] *Germany Science, Nanotechnologies in Germany*, Information file for Science and Technology by the Embassy of France in Germany, Free Publication at the French Embassy in Germany, ISBN 2-907531-05-0, october 2005.

German non-university public research in nanotechnologies is concentrated in four research institutes: MPG, FhG, HGF, WGL (see Appendix 1: Germany, appendices 1 and 2). These institutes support a large number of research centers and work groups which also cover major nanotechnology research. These partners are also integrated into various related research areas involved and into DFG programs. This initiative was started two years before the USA started their own national initiative, and four years before the European Union took similar measures within the 6th Research and Development Framework Program (PCRD).

In the field of nanotechnologies, Germany can rely on top scientists, a widespread research and development network, and engaged engineers and entrepreneurs. In addition to innovative companies, government agencies provides significant funding to promote this field and related stakeholders. Necessary measures are being introduced, such as implementation of networks, establishment of nanotechnology industrial sectors, renewal of scientific talent and integration of society in this field. Germany is the nanotechnology leader in Europe, in terms of dedicated public funding and of number of private companies, research institutes or other university bodies involved.

In Germany, science policy is directed more towards dissemination of scientific and technological knowledge, and is part of a decentralization tradition, where Länder enjoy great autonomy. Science policy, including technology transfer, falls within the jurisdiction of Länder. Development of university/private industry partnerships is mostly based on local politics. However, the issue of a need for greater federal involvement arose recently, in support of BMBF initiatives.

In the field of nanotechnologies, German stakeholders were among the first worldwide to search for application opportunities through deeper basic research. More than 200 German companies have already taken advantage of this opportunity for innovation, and nanotechnology knowledge is part of their main activities. There are currently 900 or 1,000 German nanotechnology companies, which use them more and more to create products, supply them or as investors[27]. For these companies, nanotechnologies are more than a fad. Rather, they prepare for future developments in potential high-employment areas, such as electronics, information technology, vehicles and machinery manufacture, chemistry, pharmacy, optics, medicine, biotechnologies, power generation and construction.

There are also many SMEs in Germany which can be described as pure nanotechnology companies. Such innovative and flexible companies belong to the value creation channel, and are a key factor in transferring knowledge from research to industry. SMEs hold key functions in most high-tech industries.

In addition to supporting conventional research projects, BMBF is increasingly trying to have the regions (Länder) develop major nanotechnology-related subjects, through strategic research cooperation, in close collaboration with economic and scientific stakeholders. Funding is made available for competitive industrial innovation projects which include the whole value creation chain (leading innovations).

[27] Private conversation with a representative of the German Ministry of Defense.

IV.3.c Priority Sectors

Intensive talks with industrialists and scientists led to new support of nanotechnologies by BMBF; as a result, about twenty industry-led cooperation projects, involving more than a hundred partners, were funded.

Such efforts stand out because of their interdisciplinary nature, with the participation of five BMBF divisions covering various leading innovative subjects, such as:

- NanoChemie (chemistry);
- Nanomaterials, in automotive (VanoMobil), in mechanical engineering, in nano-reinforced and multi-function materials (Hybrids and Ceramics), for example;
- NanoLux, development of effective lighting sources from semiconductors;
- NanoForLife, providing nanomaterials and nano-biotechnology products for public health;
- NanoFab, for Nano electronics manufacturing processes;
- NanoSystems, for micro objects;
- Nano-optics/ microelectronics and ITC;
- Nano-pharmacy/ cosmetics;
- Nanobiotechnologies,
- Nanotechnologies for energy engineering;
- Nano-robots and artificial muscles;
- NanoTecture (architecture, constructions);
- NanoTextil (textile applications);
- Nano-environment for filtration membranes,
- …

In the context of the German government 2020 High-Tech Strategy, BMBF decided in January 2011 to continue its “Nano-Initiative / 2010 Action Plan” with a 2015 action plan. The purpose is to achieve safe and sustainable nanotechnology, so as:

- to take advantage of its potential in educating and research;to contribute to economic growth and innovation in Germany;
- to take advantage of nanotechnology opportunities in health care;
- to reap nanotechnology’s contributions for environment, climate protection and energy supply;
- provide for less energy-consuming mobility while respecting the environment;
- use nanotechnology for sustainable agriculture and secure food supply.

Clearly identified priority areas are climate, energy, health/food/agriculture, mobility, security and communication. Figure 19 shows nanotechnology funding between 2005 and 2010.

M€	2005	2006	2007	2008	2009	2010
BMBF	125	134	146			200
BMWi	26	26	26			
Others support		11	10			
Institutional support	161	162	163			
Total	312	333	345		382	400

Figure 18. Chart nanotechnologies funding in Germany (M€).

As a comparison, international support (source: OECD 2009) to nanotechnologies amounted to about € 1,200 million in the USA, € 580 million in Japan, and € 620 million in Russia.

Defense and security-related programs

Optics is basically dual; nanotechnologies have strong impact on developments, from evolving products to distant future concepts:

a) Market introduction (3 years):

- nano-resolution optical microscopy
- OLED
- CNT-based displays
- 2D photonic crystals

b) Prototypes (4-10 years):

- EUV optics for lithography;
- “quantum dot” lasers;
- Quantum cryptography;
- - 3D photonic crystals.

c) Concepts (over 10 years):

- All-optical computing;
- Optical metamaterials (camouflage);
- Data transmission via surface plasmons.

The table above does not include German Ministry of Defense (BMVg) funding Figures. This Ministry mostly supports military and/or dual efforts as part of the Fraunhofer VVS (*Fraunhofer Verbund Verteidigungs et Sicherheitsforschung*), which includes former

Institutes like *Forschungsgesellschaft für Angewandte Naturwissenschaften* (FGAN), made up of the 3 institutes FhG FHR, FhG FKIE and FhG IOSB whose work are mainly of a military nature.

IV.3.d Evolution of the number of patents

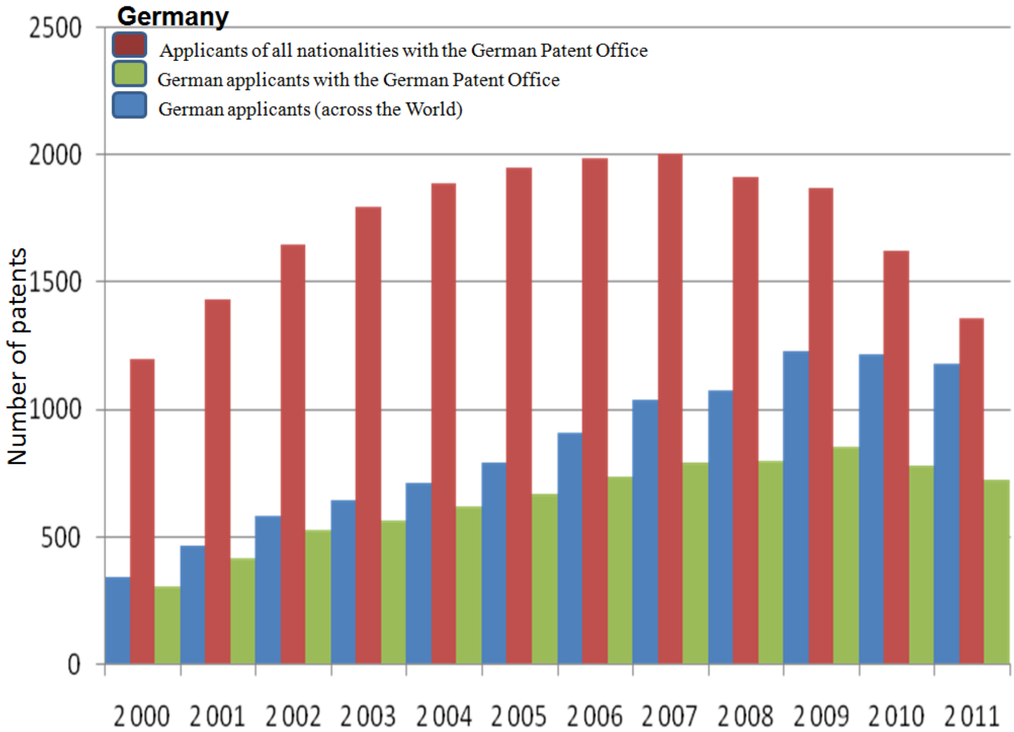

Figure 19. Patents issued in Germany between 2000 and 2011.

Number of nanotech patent applications in Germany (Figure 19) is relatively low (ranking 5th position in the study list). Regardless of applicants citizenship, an increase was observed from 2000 to 2007, then a drop between 2008 and 2011[28]. Over all procedures, the number of German applicants increase similarly, but the drop starts in 2011. In Germany, science policy is more targeted towards scientific knowledge in itself, and nanotechnologies are barely linked to applied R & D, which can explain the low number of patents.

IV.3.e Types of companies

In Germany, international cooperation between universities, research centers, institutes and businesses (SMEs/SMIs, large corporations) has grown with various partners all over the world, like other sectors of German industry. Nanotechnologies are no exception, both with respect to R & D and to industry.

The number of nanotechnology-related companies created every year in Germany has grown sharply in the past twenty years, as shown in Figure 20.

[28] That is correlated with the graph of nanotechnology start up creations in Germany from 1988 to 2011

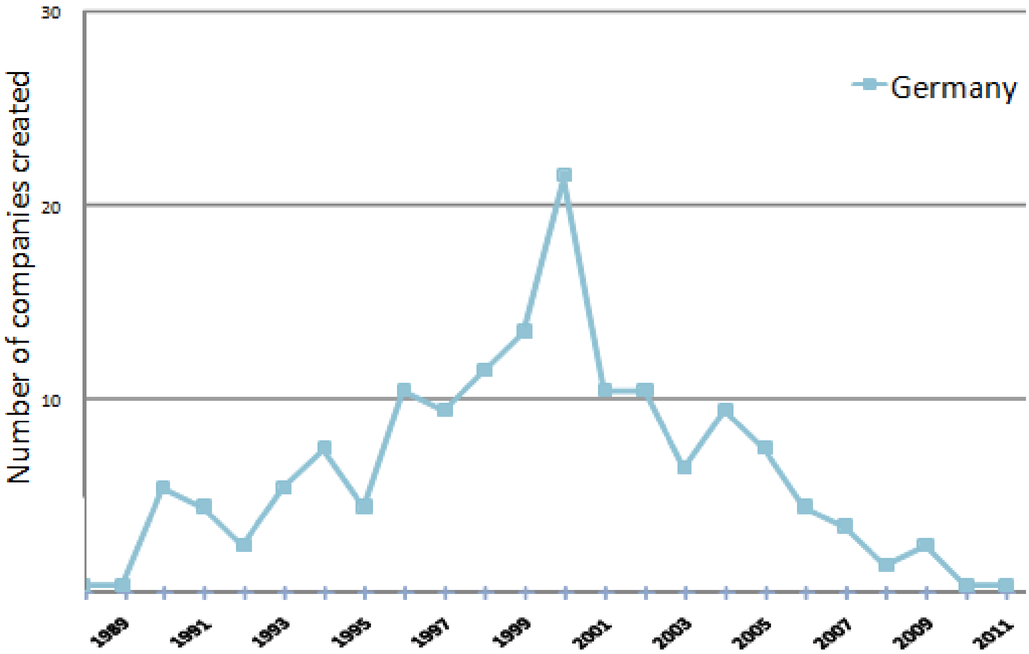

Figure 20. Creation of 143 nanotech companies in Germany – 1988-2011.

The total number of recorded companies is 222, 143 of which being created in 1988-2011.

Germany has a strong nanotechnology industrial base (second place among 13 studied countries). Compared to other surveyed countries, Germany seems to have been a forerunner in the creation of nanotech based companies, most likely, in some cases, based on microelectronics and biotechnology companies created during the 1970s. Such early start (existence of a high-tech industrial network and good level of research) should have enabled Germany to ensure the hi-tech industry to evolve quickly toward nanotechnologies. The increase of nanotech company creation started around 1998, when government funding began in earnest. It reached its peak in 2000, and then abruptly declined from 2001 to 2003. There was a slight upturn in 2004, possibly linked to the “German Future Initiative for Nanotechnologies” program, initiated that same year. But the drop recurred in 2005. Support for nanotech, which was increased from 2005 to 2007, has therefore not helped to maintain a high annual number of new companies. Since 2008, creation of nanotechnology-related companies is almost nonexistent; this situation may be partly related to the state of the global economy.

Figure 21 shows that all business sectors are represented.

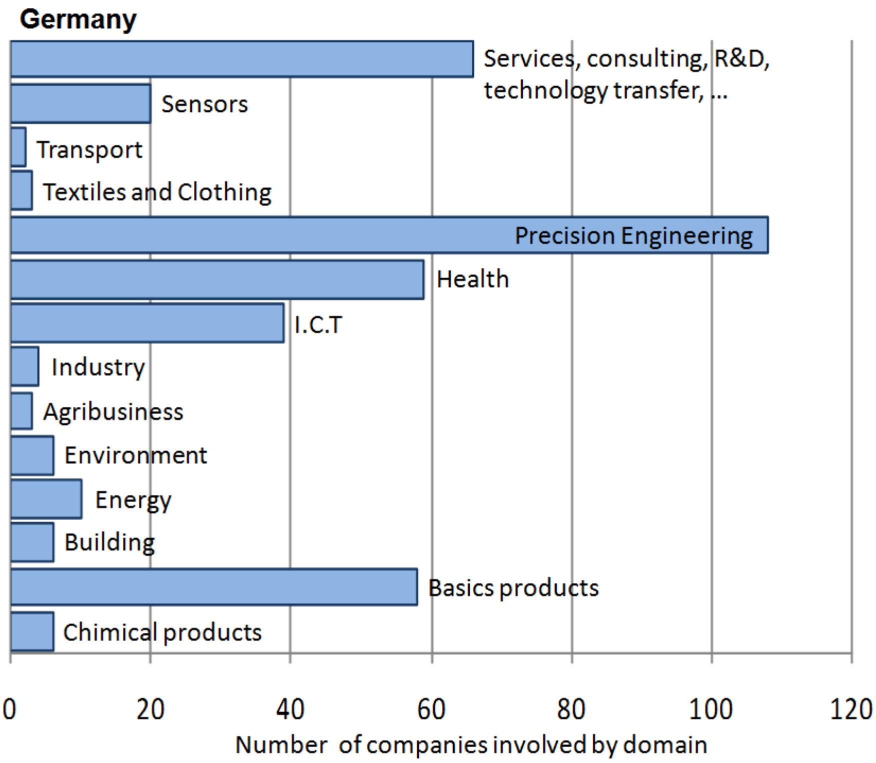

Figure 21. Distribution of the 222 German companies by field.

The most represented areas are precision engineering, medicine, commodities and services.

Figure 22 shows distribution (in percent) of German companies in the 10 areas identified as potentially related to military and / or security applications.

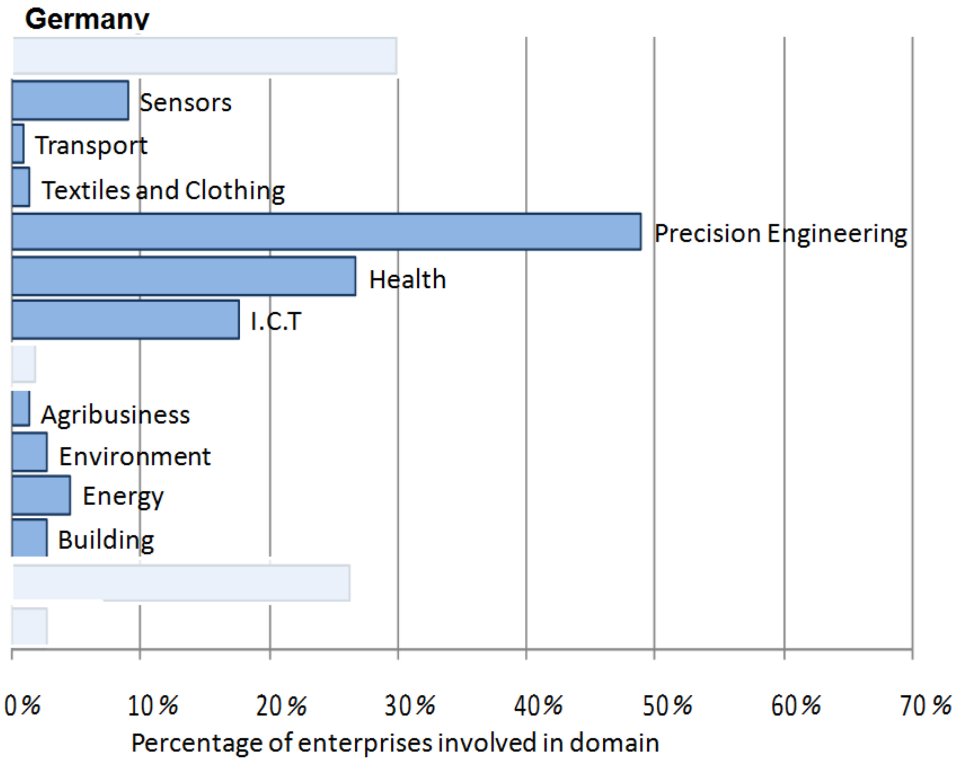

Figure 22. Distribution (percent) of German companies in the 10 selected areas.

Based on these criteria, German companies appear to be strong in the precision engineering and medical fields, whereas they are at an intermediate level with respect to ICT and sensors.

Conclusion

Germany, together with the USA and Israel, is a reference country with respect to nanotechnologies.

Keeping a permanent scientific and technological monitoring of that country[29] is warranted. Like Israel, Germany has structured research, institutes and industry by means of joint programming between funding agencies, such as BMBF and the Federal Ministry of Defense[30].

[29] French Embassy in Berlin, EU Projects in Brussels in which that country is involved, NATO, the Helmholtz Association and the German Ministry of Defense.

[30] *Bundesministerium der Verteidigung* (BMVg).

IV.4 BRAZIL

IV.4.a Data base

Population (2011)	192 millions
Area	8 million sq. km
Average density	8,3 residents/sq. km
GDP (2011)	USD 2,517 billions
GDP/capita	$10,816 $
HDI (2010)	0.813

The Federal Republic of Brazil is a great democracy, politically stable, which has been among the top ten world economies for more than a decade; However, it also has characteristics of developing countries. Partly covered by the Amazon, the largest forest basin in the world, Brazil is one of the wealthiest countries of the world in terms of biodiversity. Brazil also has significant sources of raw material, such as oil, neodymium (rare earth elements)[31], etc.

The national Brazilian research and innovation system, SNRI, is young and complicated, but features a solid architecture (see Appendix 2: Brazil). It is a good quality system, but it suffers from insufficient human and financial resources, even though significant efforts have been made in the past ten years.

Brazilian investment in research and technological development has been suffering from instability due to recurrent economic difficulties. The share of private companies R & D remains very low.

IV.4.b Brazil's efforts

Strong government support

National nanotechnology development policy in Brazil began after a conference held in November 2000 in Brasilia, about trends in nanoscience and nanotechnologies. This major event was organized by the Political Secretariat, the Ministry of Science & Technology and the National Scientific Research Council (CNPq). During this meeting, 32 researchers from different disciplines came to an agreement about the need to create a nanoscience and nanotechnologies program. In 2001, as a follow-up to this conference, CNPq called for interdisciplinary and multidisciplinary research projects in order to run *Redes Cooperativas de Pesquisa Bàsica e Applicada en Nanociências e Nanotecnologias* (Cooperative Networks for Basic and Applied Research in Nanoscience's and Nanotechnologies) in order to create and consolidate national expertise in this field. Four research networks have been created: nanostructured materials, molecular and interphase nanotechnology, nanobiotechnologies, and nano-instruments semiconductors and nanostructured materials network.

[31] CECILIA JAMASMIE, $8.4 billion rare earth deposit discovered in Brazil, Mining, 9 avril 2012.

In 2002, the Ministry of Science and Technology (MCT) created an institute for nanoscience in Belo Horizonte as part of the Millennium initiative.

In 2003, when President Luis Inacio da Silva (who was strongly committed to nanotechnologies) was elected, MCT created a new program, supervised by Dr. Fernando Galembeck (Professor at the University of Campinas).

Although commitment to nanotechnologies started in 2000, it was only in 2004 that the government acknowledges this sector as forward looking. The government supports public research but also public-private cooperation [32].

In 2005, the four networks installed in 2001 were extended to 10 (see Appendix 2, Figure 77), all connected to Brazil Nano program.

investment was consolidated through MTC's 2004-2007 Multi-Year Plan. (See Figure 23)

By the end of 2006, 106 research projects were running (50 in research, 46 involving companies, 5 in international cooperation and 5 about social and environmental impact). Under the February 2007Biotechnology Development Policy, nanotechnologies and nanoscience are considered as an important contribution to future technological developments, with applications in biomaterials, human health, agriculture and industrial biotechnologies.

Financing	**Budget**
Nanotechnology networks 2001-2003 (CNPq)	R$3 million
Millennium Institutes 2001-2004	R$22.5 million
Nanotechnology networks 2003-2004	R$5 million
Sectorial funds 2003-2005	R$6.7 million
Program Development of Nanoscience and Nanotechnology (PPA 2004-2007) 2004-2006	R$8.4 million
Sectorial funds 2004-2006	R$9.1 million
RHAE Innovation 2004-2006	R$7.1 million
National Nanotechnology program 2005-2009	R$58.6 million
Millennium institutes and microelectronics call 2005-2008	R$ 21.5 million
National nanotechnology program call 2006	R$28.4 million
2001-2006 Total	**R$170.2 million (€61.6 millions)**

Figure 23. R&D funding in Brazil.

[32] However, publication as original author is predominantly from academia: 78,4%, Government: 5% private industry: 0.2% Public Industry: 0.8%, Hospital: 0.1, (other being the foreign authors of publications). *Nanotechnology in Latia America*, Luiciano Kay, 2006.

Nanotechnology research centers in Brazil

There is no central point where Brazilian research in Nanotechnologies is concentrated. However, some cities can be considered as network nodes. The Brazilian government has made investments in nanotechnology research facilities, such as the LNLS synchrotron, the Inmetro metrology institute, the CBPF physics research center and the EMBRAPA Center for Agricultural Research. (Appendix 2, Figure 79).

IV.4.c Priority Sectors

Brazil work on a number of industrial application areas such as aerospace, agro-industry, cosmetics and health care, energy, environment and textiles. Brazil has acquired knowledge in: nanotechnology, nanobiostructures, nanophotonics, molecular nanotechnology, nanobiomagnetism, nanoscience, nanocoatings, simulation and modelization, nanocosmetics, nanoglicobiotechnology. However, publishing activity is focused on [33]:

- Physics: 44.5%
- Chemistry: 22.3%
- Materials Science: 32%
- Engineering: 7.1%
- Medicine: 5.7%
- Biology: 4.9%
- Electronics: 4.5%
- ….

Law

The issue of ethical, social and risks associated with the use of nanotechnologies emerged in 2004, in particular through creation of the Brazilian Nanotechnology, Society and Environment Network Foundation. Brazilian scientists had introduced nanotechnologies as a revolutionary area with a huge market potential. To avoid being left behind in the international race, social impacts and risk had been dismissed so they could not cast a shadow over an optimistic view of the future of nanotechnologies. A public debate was organized, but it split the country. Concerns of NGOs and social scientists include risks to short-term health, and environmental impact. They also consider that the priorities of nanotechnology research are not appropriate for societal needs.

The need to analyze ethical implications and social impacts derived from dissemination of nanotechnology products is part of the public document of the Ministry of Science and Technology 2007 to 2010 action plan (in which nanotechnologies play an important role).

[33] *Nanotechnology in Latia America*, Luiciano Kay, 2006.

IV.4.d Brazil on the worldwide stage

Collaboration in R&D

Brazilian scientific work is well internationalized. With 40.3% of international co-publications (including 31.7% with the United States, 10% with France and 9.5% with the UK, etc.) in its publications in 2001, Brazil is at the same level as France or Canada based on this criteria, and ten points above China

In 1992, the EU and Brazil have entered into a framework cooperation agreement and, in 2004, a technological cooperation agreement. A strategy paper has been established for 2007-2013. That strategy governs development cooperation activities, and has a € 61 million budget. Priorities defined are:

- To increase exchanges, contacts and knowledge transfer how between the European Community and Brazil: To support sector-related dialogues; To use higher education program (€ 30.5 million) to strengthen links between the European Union and Brazilian academic communities; To create an Institute of European Studies in Brazil.
- To support environmental and sustainable development projects in Brazil.

The EU wants to stimulate research collaborations between European and Latin American nanotechnology researchers via the 7th PCRD.

Many R & D partnerships are with bordering countries. Indeed, Argentine RCBC center of nanotechnology is in Porto Alegre. It is very active in promoting development of human resources in both countries. There are also:

- A Brazilian-Mexican virtual nanotechnology center, designed to finance collaborative projects between those countries.A virtual nanotechnology center: “Centro Brasileiro de Nanociencia Argentino y Nanotecnologia” (CABNN), which uses the facilities of both countries to develop joint projects, increase human resources, and exchanges.

Collaboration in industry

Figure 24. Brazilian international Cooperation and investment.

Figure 24 shows global Brazilian investments and cooperation.

1. Brazil, which is nanotechnology research leader in Latin America, has a partnership with South Africa and India to promote South-South cooperation via the IBSA Initiative on Nanotechnology[34].

2. A common center bringing Brazil and China together for research and innovation in nanotechnology (CBC-Nano) has been created. Its missions are:

- to develop cooperative research and development program;

- to promote scientific and technological advances in research and application of materials using nanostructures;

- to consolidate and expand research in the field, and increase scientific training [35].

China has shown interest in developing with Brazil sensors and medical diagnosis equipment.

3. The state-owned Brazilian Agriculture Research Company, EMBRAPA, has announced opening of a new virtual laboratory (Labex) in South Korea, in order to work in China and Japan. Embrapa wants to improve its knowledge of local sanitary and phytosanitary control systems, so that Brazilian products fit regional markets. This approach will also allow access to genetic resource banks in Asia [36].

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[34] Priya Shetty, *Nanotechnology for health: Facts and Figures, SciDevNet, Science and Development Network, November 24, 2010*.

[35] China & Brazil Set Up Joint Nanotechnology hub in Sao Paulo, Asian scientist newsroom, 6 2011.

[36] Brazil: Embrapa opens virtual lab in South Korea to act in China and Japan, macauhub, November 21, 2008.

4. A Brazil-UK collaboration, within the framework of a bioscience innovation network, to enable knowledge transfer and promote interaction of *Biosciences KTN* members with part of Brazil investment community. This network will act as venture-capital in Brazil, and will have direct access to UK companies that are well-matched to the Brazilian biotechnology markets and the member firms that might be interested in seeking financing and / or collaboration in Brazil.

5. Within the framework of Brazil-Portugal cooperation, a nanotechnology workshop took place at PFBC (Brazilian Physics Research Center of the Ministry of Science and Technology, in Rio de Janeiro) as part of the Protocol between Portugal's Ministry of Science, Technology and Higher Education, and of Brazil's Ministry of Science and Technology[37].

6. Costa Rica and Brazil cooperate in the nanotechnology and aerospace engineering fields[38].

It is notable that collaborations identified in this study are highly focused on R&D.

[37] 1st Brazil-Portugal International Cooperation in Nanotechnology Workshop, UMIC, Ministry of education and science, july 17, 2010.

[38] *Costa Rica & Brazil Cooperate in Nanotechnology & Aerospace Engineering*, MICITI, Ministerio de ciencia y tecnologia, November 23, 2010.

IV.4.e Evolution of number of patents

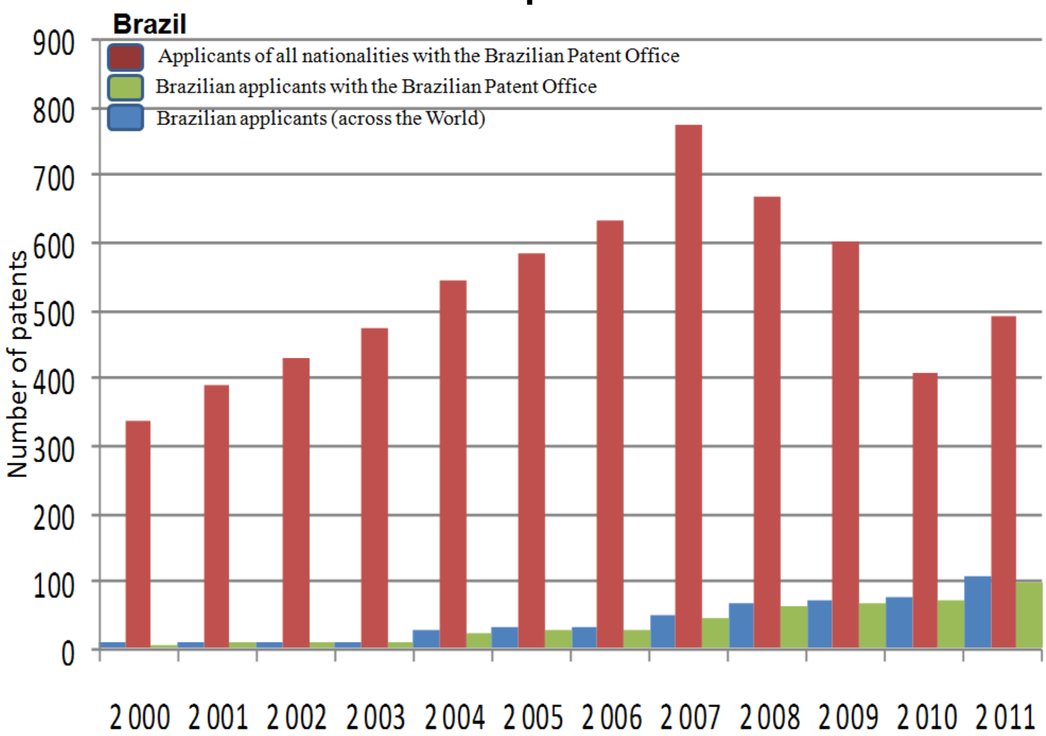

Figure 25. Patents published in Brazil from 2000 to 2011.

Practically all of the R&D budget comes from the government. Brazilian researchers prefer publishing papers to applying for patents; however, this approach encourages foreign companies to benefit from research. The government has therefore taken measures to remedy this issue, and to avoid a brain drain towards countries emerging in this field such as China, Russia, etc. Figure 25 shows that such a patent application approach slowly becoming effective in Brazil, as applications have been growing steadily. The number of patent applications filed in Brazil is still very low; and Brazil ranks 12th of the 13 countries in this study.

In addition, there is a wide gap between Brazilian applicants, and applicants from all other countries. It seems that the number of patents filed by foreign nationals has increased between 2000 and 2007, then has dropped sharply.

Patent statistics show that the Brazilian system is still experiencing difficulties to convert scientific advances into technological innovations and commercial applications.

IV.4.f Types of companies

The resources used for this study did not reveal a nanotechnology industrial base in. This lack of information does not imply that there are no such base, but the lack of Infogreffe-like data base in this country makes it difficult to reveal it. However, innovation surveys covering the period 1998-2000, performed according to a methodology compatible with Brazil and Europe, show that only 4% of Brazilian industrial companies market innovative products, compared to 18% in France[39]. This survey is consistent with the results obtained, which suggest that commercialization of public research is low. In addition, public research occurs prior to product development, and therefore not really in phase with industry. I tis hoped that, a few years from now, knowledge acquired will be converted into marketable products.

Conclusion

Brazil has followed the international trend since 2000 by focusing on nanotechnologies. The nanotechnology and nanoscience policy started during Fernando Henrique Cardoso's administration (1999 to 2002) was designed to create a Nanotechnology Reference Center linked to MCT. This center had a dual mission: stimulating university research and encouraging the use of new technologies in the private sector. In terms of the number of publications and patents, Brazil is nanotechnology leader in the South American region (Argentina, Uruguay, and Chile)[40]. Despite Brazilian multidisciplinary programs, most publications are concentrated on physics, chemistry and materials science.

Although such a policy, pursued by Lula, has created many nanotechnology research centers and international cooperation, a real industrial fabric has, however, not emerged. It is therefore critical for Brazil to acquire institutions in order to facilitate the transfer of technology.

The possibilities for upgrading and optimizing bilateral cooperation, without increase in funding, should take into account scientific priorities announced by French and Brazilian authorities, both of which are focused on development of innovation and technology transfer, essential to competitiveness.

Brazil does not seem to be a key industrial partner for France, but might be a candidate for interesting nanotechnology research collaborations.

[39] *Brazilian Scientists Embrace Nanotechnologies*, Invernizzi, Noela, RELANS, 2007.

[40] The Universities of Sao Paulo and Campinas account alone 34 percent of the South American publications.

IV.5 China

IV.5.a Data base

Population (2011)	1.34 billions
Area	9.6 million sq. km
Average Density	140 residents/sq. km
GDP (2011)	USD 7,000 billion
GDP/capita	$5,200
HDI (2009)	0.77

IV.5.b China's efforts [41]

The Popular Republic of China considers nanoscience and nanotechnologies (NST) as the way for the future, especially in economic terms, and has implemented a number of programs to develop this sector.

In 2006, the Chinese government launched, via the Business Council, a long-term national plan (2006 to 2020) devoted to scientific and technological development of the country where NST were taking a growing place.

A proactive research, industrialization and marketing policy for products and technologies started, amplifying the effort that had existed since the 2000s

Very significant funds were allocated by the State for several R & D programs, including the National Research Plan, plan 863 and plan 973. Investments amounted to approximately 760 million dollars from 2006 to 2010, an increase of nearly 300% over the period from 2001 to 2005.

NST publications and patent applications grew very rapidly from 2000 to 2010, reflecting the importance of government support and the attractiveness of new topics for researchers. (See Figure 26)

China currently ranks first worldwide with respect to number of nanotechnology patents filed, having surpassed the United States since 2010.

The country appears to have currently more than 350 universities, around thirty research institutes and over 400 companies involved in the NST, with a global workforce of

[41] ALAIN DE NIEVE, *Panorama of programs and investments in nanotechnology, Agoravox, October 20, 2009.*

JIM WANG, *Development of nanotechnology in China, Association* China Nanotech.

ZOE LOMBARD, *Balance from the XIth Five Year Plan for nanosciences, China is developing its own nano-object standardization device BE China No. 100, January 28, 2011*.

China's Program for Science and Technology Modernization: Implications for American Competitiveness, U.S.-China economic and security review commission, CENTRA Technology, Inc, Micah Springut, Stephen Schlaikjer, janvier 2011.

Military, Arms Control, and Security Aspects of Nanotechnology, Jürgen Altmann and Mark A. Gubrud, Institut für Experimentalphysik, Universität Dortmund, 2004.

approximately 26,000 researchers. The government is also investing heavily in industrializing research, and is facilitating the commercialization of products derived thereof [42].

In the north, the Beijing National Centre for Nanoscience's.

- In the northeast, the National nanotechnologies Research Institute and Tianjin Engineering.
- In the south, the National Applied Nanotechnologies and Engineering Center in Shanghai.

The Beijing Nanoscience's National Center includes a large number of academies, universities and institutions: the Chinese Academy of Sciences, the Institute for Research on iron and steel for China, the Polytechnic University Beijing, the Academy for building materials of Pekin, Peking University, Pekin University of Technology, Tsinghua University, Technological University of Chemistry, Tianjin University, Nankai University and those of Jilin.

The Shanghai National Center mainly brings together: the Chinese Academy of Sciences, University of Science and Technology of China, the Technology University of East China, the Institute of Physics and Technology in Shanghai, the Shanghai Jiaotong University, Fudan University, Tongji University, Zhejiang University, Nanjing University and the one of Shandong.

These two centers represent 80% of the country NST activity.

[42] A convincing example is the International nanotechnologies Innovation Park in Suzhou, which has more than doubled its sales from 2008 to 2009, with a profit of nearly $ 400 million in 2009 and a similar level of growth in 2010.

IV.4.d Evolution of the number of patents

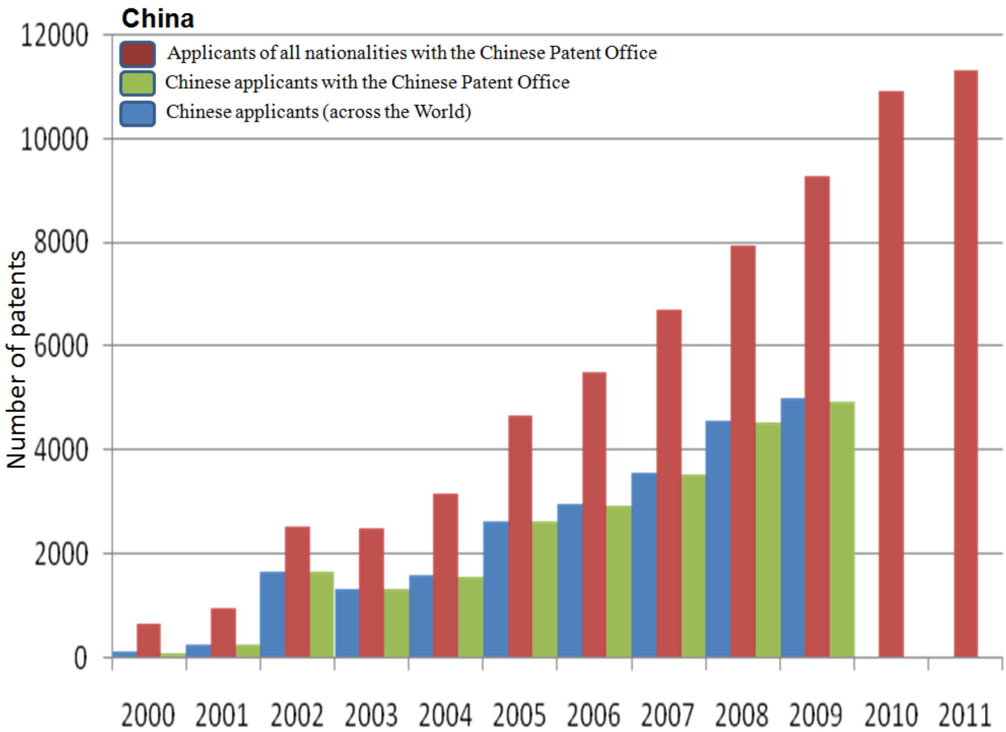

Figure 26. Patents published in China from 2000 to 2011.

China currently ranks first worldwide with respect to number of nanotechnology patents filed, having surpassed the United States since 2010. Growth has been constant and very strong from 2000 to 2011.

IV.5.e Types of companies

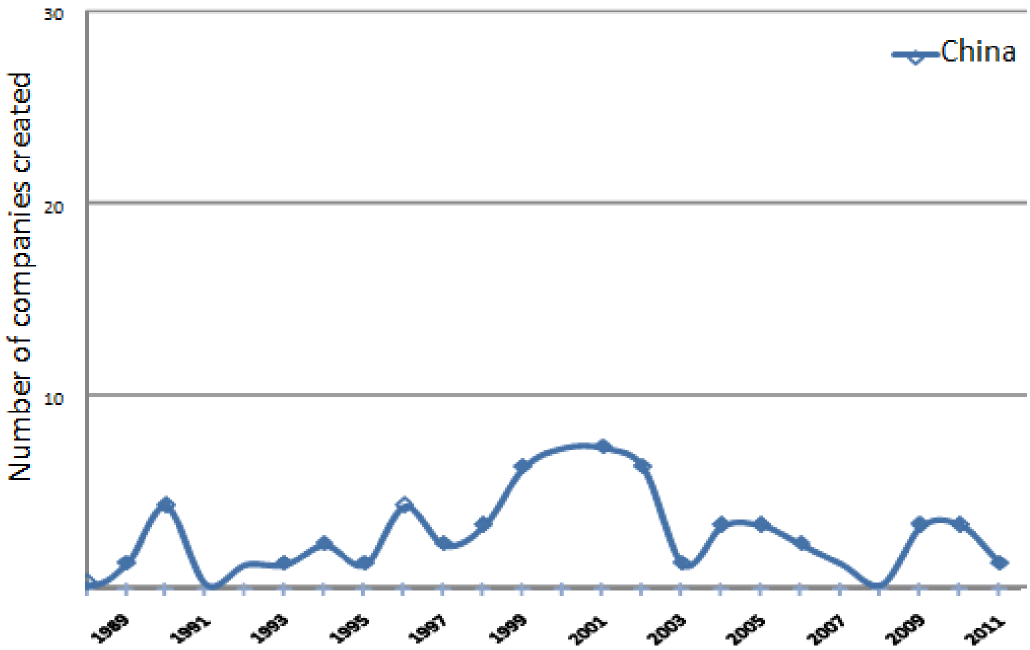

Figure 27. 62 nanotechnologies companies created in China 1988-2011.

The total number of companies in this study is 75, of which 62 were created from 1988 to 2011. Activity started in a small scale in 1990, with a more real start in 1996. Like many other countries, the 2001 peak was followed by a decline, even though a small recovery took place in 2009 and 2011.

Figure 27 shows the number of Chinese companies involved in the various nanotechnology fields. All fields are represented except food.

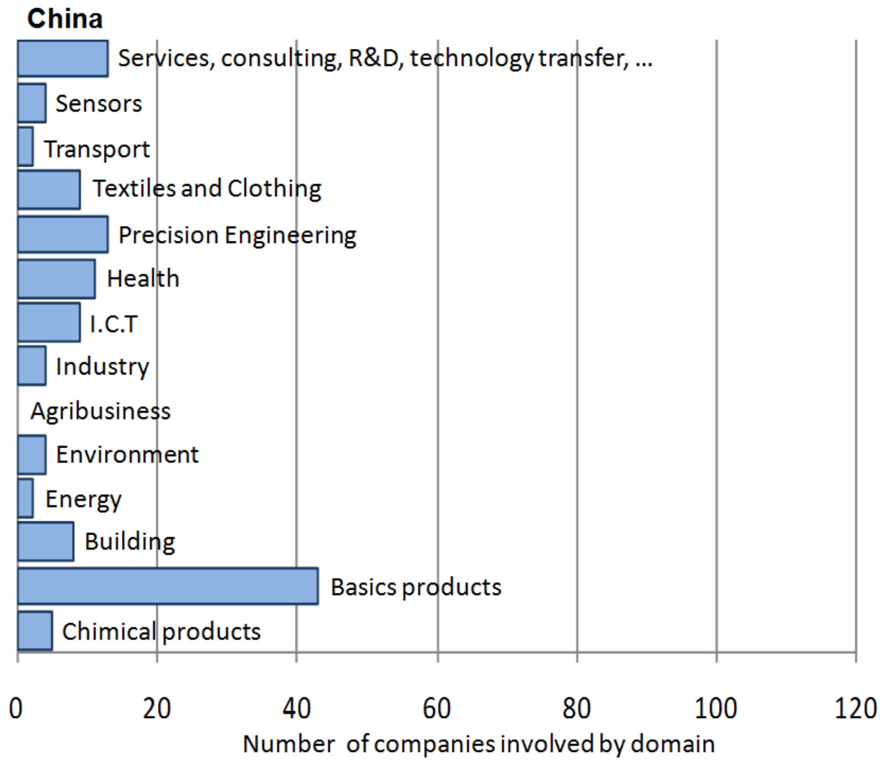

Figure 28. Distribution of the 75 Chinese companies in this study.

Although, in all likelihood, these 75 companies represent only a small part[43] of all existing companies, this sample gives a good indication of the most developed categories.

Figure 29 shows companies in this study, by percentage, compared to the 75 under study, in the 10 areas identified as potentially related to military and / or security applications.

[43] Start-ups are difficult to identify compared to companies engaged in R&D.

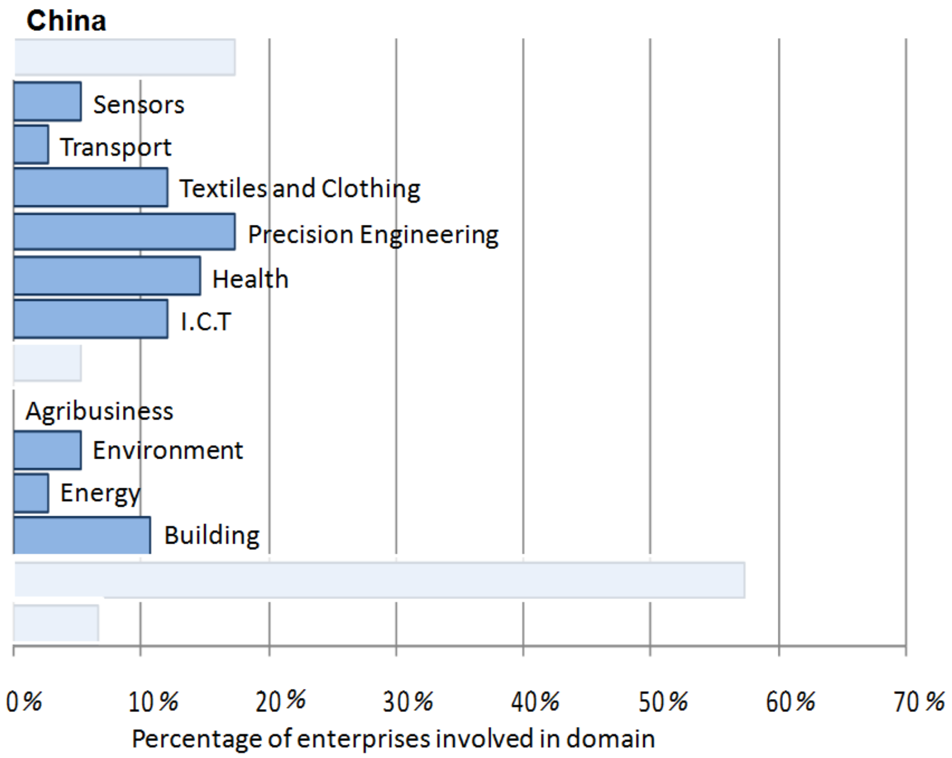

Figure 29. Distribution (%)of the 75 Chinese companies in this study.

The criteria[44] used reveal no strong capacity, which means that China has diversified capacities. However, precision mechanics, medicine, ITC, textiles and clothing, and construction, are positioned at an intermediate level as well as, but to a lesser degree, sensors and environment.

Conclusion

It clearly appears that Chinese nanotech companies are mostly present in "commodities" (nano-powders, nano tubes, nano alloys, etc.); other fields are way further down. It is likely that these will grow in the coming years.

Purchase of specialized products from Chinese companies could therefore, if necessary, meet some French needs.

[44] See section IV. 1 of the report

IV.6. South Korea

IV.6.a Data base

Population (2011)	48,754 millions
Area	99,274 sq. km
Average density	488 residents/sq. km
GDP (2011)	$1.356 billions
GDP/capita (2011)	$27,813
HDI (2011)	0.897

IV.6.b Korea's efforts

The Republic of Korea spends, for its R&D programs devoted to nanoscience and nanotechnology, significant amounts: about 3.5% of the GDP. This R&D effort is organized around co-financed Public-Private Partnerships. The country is committed to a third phase of industrial development, following the two initial phases, based respectively on development of light industries, then on heavy and mechanical industries. Priority is now given to sectors deemed to be the way of the future, including development of Services[45]. A recently-implemented decentralization policy is designed to develop regional poles in a still highly centralized state (see Appendix 3: South Korea, Appendix 1). Korea also has a policy of active international collaboration designed to improve skills in state-of-the-art technological fields[46].

Founded in 1999, the National Science and Technology Council (NTSC) defines priorities, and is responsible for coordinating effectively countrywide Science and Technology policies and R&D programs. Chaired by the President of the Republic, it is made up of scientists and technological government ministers, and representatives of academia and industry. (see Appendix 3: South Korea, Appendix 2)

South Korea ranks 4th among the 15 most important global nanotechnology research centers (see Figure 30).

[45] *Statistical Yearbook of Education 2011*, MEST and Ministry of Education, Science and Technology: http://www.mest.go.kr

[46] *Research and Technology in South Korea, Scientific Section of the Embassy of France, in September 2009.*

Countries	Cities	Number of addresses	% change (1998-2006)
Japan	Tokyo	35363	69
China	Beijing	26492	410
Japan	Kyoto	22285	74
South Korea	Seoul	20343	263
France	Paris	16385	55
USA	Berkeley	16176	100
Japan	Tsukuba	14003	234
USA	Washington	13292	102
China	Shanghai	12347	519
USA	Boston	11650	124
Russia	Moscow	10368	60
Singapore	Singapore	10256	423
Germany	Berlin	9065	57
Taiwan	Hsinchu	9057	251
Japan	Nagoya	8575	112

Figure 30. 15 most important nanotechnology clusters and their growth rate.

According to the Swiss *International Institute for Management Development* (IMD), Korea ranked, at the international level, 38th in terms of scientific competitiveness, 12th in terms of technological competitiveness and 6th in terms of national competitiveness. (see Appendix 3: South Korea, Appendix 3).

IV.6.c Priority sectors

In nanotechnology, South Korea favors a systemic approach, and bolsters convergence between ITC, biotechnology and energy-transportation.

From 2005 to 2007, South Korea showed continued strong growth in nanotechnologies (Figure 31), thus ranking between 5th and 10th worldwide, according to market researches. [47].

[47] A) Competitiveness of Various Countries in NT, (Lux Research Report, Dec. 2007) – B) Avis et rapports du Conseil Economique et Social: Les Nanotechnologies, M. Alain Obadia, 2008 N°21 NOR: C.E.S. X08000121V – C) Emerging Nanotechnologies power - Nanotechnology R&D and Business Trends in the Asia Pacific Rim, © World Scientific Publishing Co. Pte. Ltd., http://www.worldscibooks.com/nanosci/7224.html

Figure 31. Competitiveness of different countries in the field of nanotechnologies.

The country has committed to a roadmap consisting of five strategic goals:

- To develop a society based on information, knowledge and intelligence;
- To enhancing health care and biology;
- To develop environment and energy industrial sectors;
- To strengthen major Korean industries (transportation, materials);
- To improve sectors of national interest (aeronautics / aerospace, food security, and preservation of natural resources);

These policies are reflected in the 8 sectors receiving the most government funds:

- Information Technologies and Electronic, the best funded sectors (33.4%)
- Biotechnology, biology (23.7 %)
- Mechanical Engineering (9.8%)
- Energy[48] / resources (9.8%)
- Basic sciences (6 %)
- Aerospace (6 %)
- Environment and Nanomaterials (about 6% each)
- Transportation, construction (5.2%)

Several major national R&D programs, specific or general, have been implemented since the early 1990s with a view to lifting the country technological capabilities to levels

[48] *Nanotechnology and the Millennium Development Goals: Water, Energy, and Agri-food*, Susan Cozzens, U.S. National Science Foundation, Center for Nanotechnology and Society at Arizona State, University under Grant No. 0531194, 10 juin 2010.

equivalent to those in other OECD countries. The government is engaged in a long-term strategy, and sets up, every 5 years, a Science and Technology Fundamental Plan[49].

- Seven priorities have been defined:
- Strengthening anchor industries (automotive, semiconductors, etc.);
- Strengthening strategic sectors (aerospace, weapons, nuclear, etc.);Defining new industrial sectors (pharmaceuticals, etc.);Promoting science and technology based on knowledge (culture, media, design, etc.);
- Treating risk issues (emerging diseases, bird flu, mad cow disease, etc.);
- Involvement in global causes (malnutrition, underdevelopment, environment, etc.);
- Development of convergence technologies.

In 2007, the Ministry of Education, Science and Technology (MEET) adjusted all its R&D investment toward priority technology fields:

1. Enhancing productive investments in nanotechnologies.
2. Increasing the links between military and public R&D.
3. Specifying biotechnology development strategies according to application areas, in particular development of new drugs.

IV.6.d Defense and security-related programs

Nanotechnology applications with more immediate strategic interests are classified as high-priority in South Korea.

Beyond the new sub-nano transistor, computer science turns to optical communication, quantum computer, or NEMS, the nano successors of Micro Electro Mechanical Systems (MEMS). Another key objective is the development of fast and economical DNA sequencing methods, which nanotechnology is expected to revolutionize.

Tensions with China, mixing control of Korea's image and military interests, have been raised by South Korea on several occasions since 2010[50]. These tensions are pushing South Korea, regarded as USA's aircraft carrier in front of China, to have available state-of-the-art technologies, and a strong and powerful industry capable of financing its military programs, while having its own dual technologies such as nanotechnologies.

[49] Latest Plan: 2008 to 2012.

[50] This included discussions in how Beijing ought to respond to Southern China Sea tensions and to joint USA-South Korea exercises in the Yellow Sea.

IV.6.e Evolution of the numbers of patents

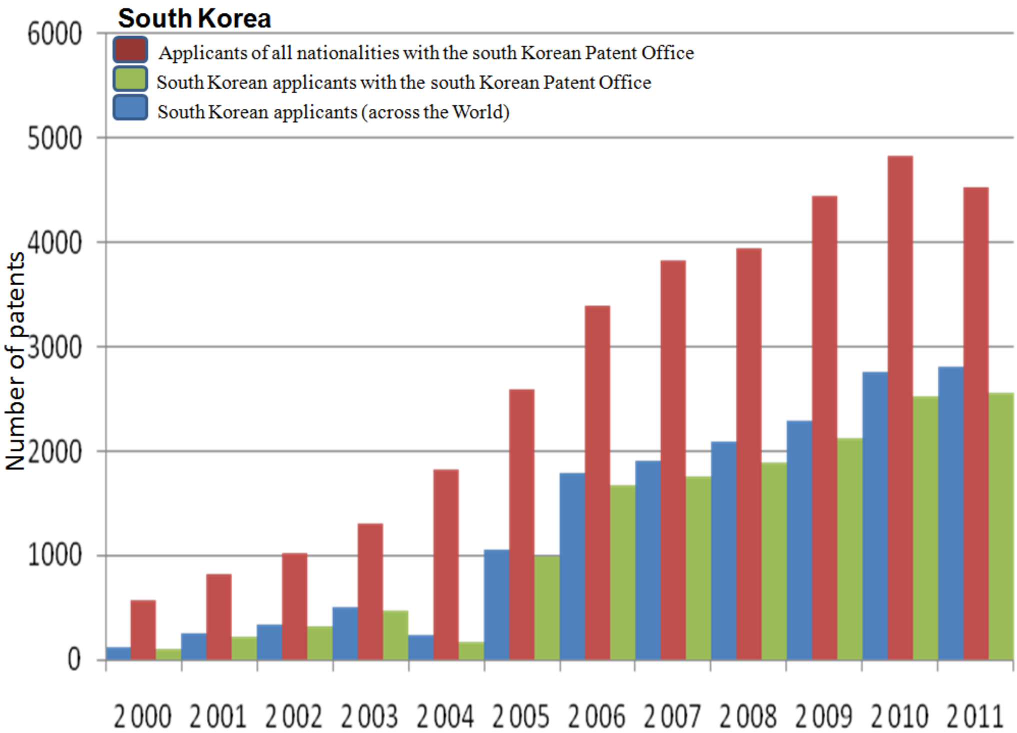

Figure 32. Patents published in South Korea between 2000 and 2011.

In terms of patent filing, South Korea's performance is impressive, as evidenced by his 4th place out of the considered 13 countries. There has been a steady growth from 2000 to 2010 (Figure 32).

IV.6.f Types of companies

South Korea is actively collaborating in R & D, in particular with the three following countries:

- France: the framework of the France / South Korea Science and Technology cooperation system helps to pay for exchanging researchers working on some thirty projects, jointly selected by both parties on scientific criteria.

  It is an exchange tool, designed for networking scientists rather than collaborative research. Management of the program is entrusted to the National Research Foundation for Korea, and the Embassy of France in Korea for France. In addition, several Korean teams are financed by multilateral programs of the French Ministry of Foreign Affairs, in the context of Franco-Asian research projects in the field of I.C.T[51].

  China: selected cooperation topics are weather forecasting, biotechnologies, new materials, environmental technologies, applied laser technologies, and the commercialization of advanced technologies. The two countries have created 4 joint research centers in Korea and 2 in China. Great Britain: South Korea signed with Great

[51] STIC-Asia Program.

Britain in 1985a first Science and Technology Cooperation Agreement. The 2 countries have prioritized the following 9 topics: Optics, biotechnologies, I.C.T., gas hydrates, creative industries, energy, environment, space, nanotechnologies. Six joint centers have been set up since 2004, of which 2 with the Cambridge University[52]. Cooperation is being developed in neurosciences and new energies.

Moreover, South Korea joined OECD in 1996. Since then, Korea has been participating actively to OECD various bodies, including the Committee for Scientific and Technological Policy (CPST). Several regional centers are located in Seoul: *International Vaccine Institute*, (*Asian Pacific Centre for Transfer Technology* APCIT).

Figure 33 shows the number of nanotechnology-related companies created every year in South Korea in recent years.

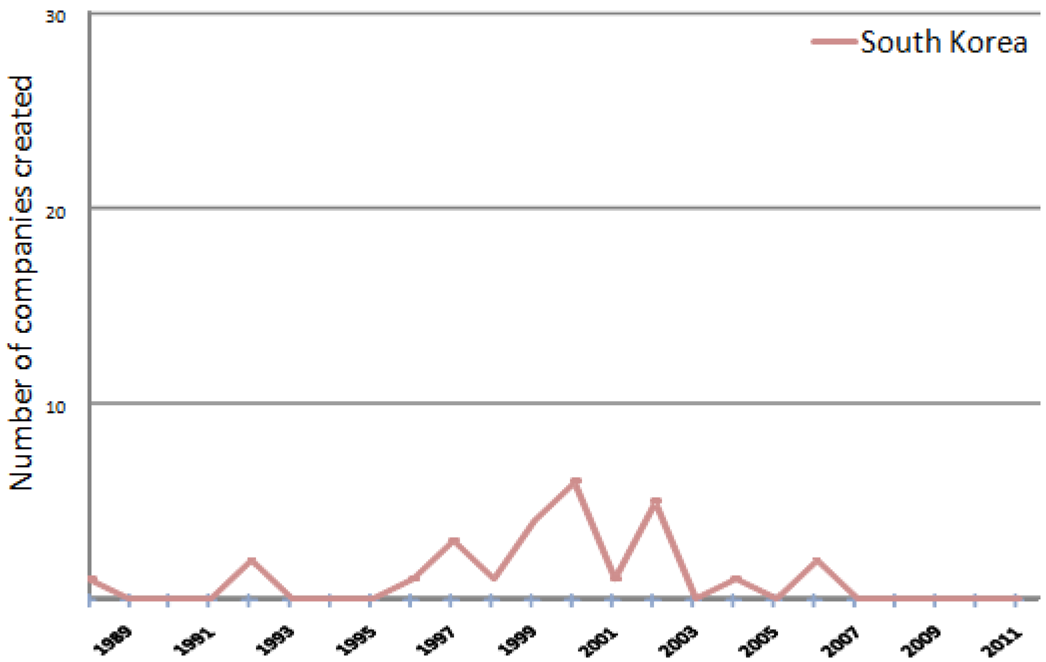

Figure 33. 27 nanotechnology companies created in South Korea – 1988-2011.

The total number of companies listed in this study is about 41, of which 27 between 1988 and 2011. South Korea therefore ranks 8th.

The largest spike was in 2000. Since then, there has been a slow decrease in Nanotechnology Company's creation. In 2007, MEST adjusted its R&D funding to include technological fields, including nanotechnology. But this measure didn't increase the number of start-ups. Figure 34 shows the areas of business activity.

[52] Each with KAIST in optoelectronics and ETRI in nano, biotechnology and ICTR.

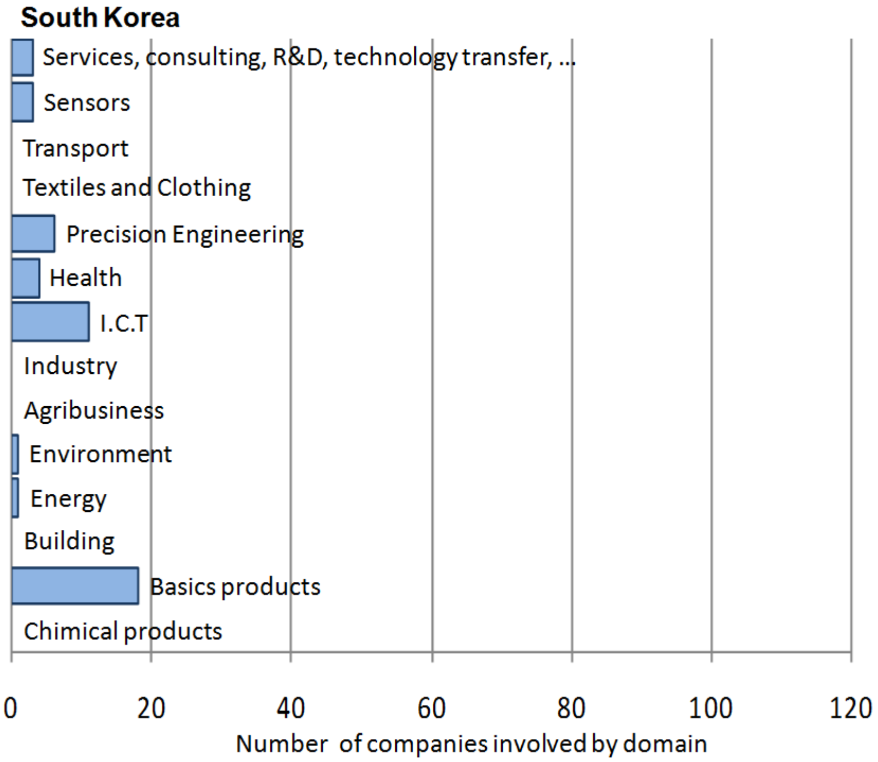

Figure 34. Distribution of 41 Korean companies in this study.

Worth noting: no companies in chemicals, construction, food processing, industry, textiles and clothing, and transportation.

The best represented areas (information and communications technology, and commodities[53]) match the roadmap South Korea wanted to follow.

Figure 35 shows the distribution (in percent) of the 41 South Korean companies in the 10 areas identified as potentially related to military and / or security applications.

[53]Meaning "including nanomaterials"

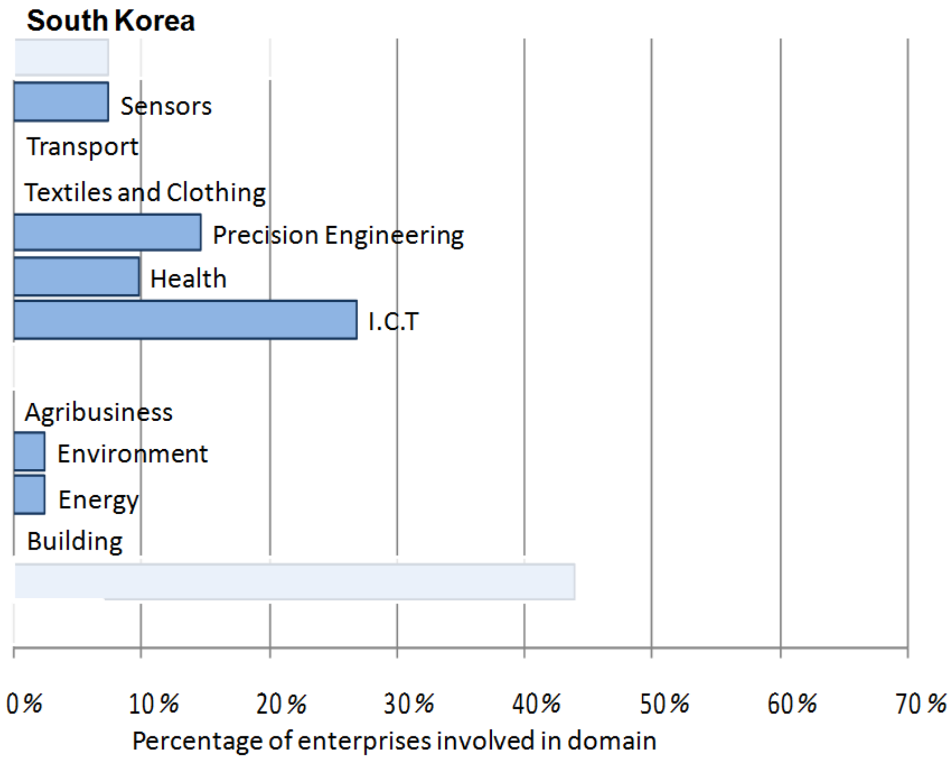

Figure 35. Distribution of Korean companies (%).

Based on these criteria, Korean companies appear to be strong in ITC, with precision engineering, medicine and sensors are at an intermediate level.

Conclusion

Contrary to France, South Korea has implemented a real government strategy on nanotechnologies, which covers universities, industry, defense, international relations, in an integrated and coordinated manner. This resulted in the creation of many sustainable jobs, and manufacturers with real leadership.

Support to technology transfer and commercialization of products is a priority, to transform research promises. The nanotechnologies program remains robust and well balanced to reinforce, in particular, its defense potential.

IV.7 United States

IV.7.a Database

Population (2012)	313 millions
Area	7,700,000 sq. km
Average Density	33.7 residents/sq. km
GDP (2011)	$15,094 billion
GDP/capital (2012)	$48 386
HDI (2012)	0.910

IV.7.b USA's efforts

Nanoscience's and nanotechnologies programs (NST)

In the late 90s, US think tanks[54] were beginning to see the possibilities of an emerging field, i.e. nanotechnologies. Their development was going to collide with the administrative division of federal agencies specialized in R&D financing. Comprehension and mastery of new phenomena and properties at the nanoscale did not just revolutionize one area - materials science, energy, information technologies, health, etc. - in particular, but all of them. Development of nanoscience, therefore, called for a wide financing program that, rather than being built independently by each agency, required all of them to come together. The solution found was a federal nanotechnology financing coordination program; created in late 2000 under the name National Nanotechnology Initiative (NNI). Within the NNI, strategic plans are updated every 3 years, to make available new tools to ensure better coordination, communication and cooperation among federal agencies. NNI has no authority over these agencies, who can freely decide their research programs. NNI's budget has been multiplied by 5 in 10 years, to around $ 2.1 billion for 2012. With $ 14 billion invested, NNI is now the largest US federal R&D financing program since the space program. Research infrastructures implemented by NNI provides a solid foundation upon which the US intend to capitalize in order to maintain their global leadership in the next decade[55]. NNI has always been supported by the White House and Congress. It survived three administrations (Clinton, Bush and Obama) and 6 Congresses. Such support, reinforced by positive feedback, has secured its very strong budget growth.

For NNI, the year 2010 was characterized by validation of its strategic plan (3rd version) and that of the EHS (Environment, Health, Security) second phase.

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[54] A *think tank,* or laboratory of ideas, is a private institution, in principle independent of political parties, non-profit, which brings together experts and produces studies and proposals in the field of public policy.

[55] *Dix ans de Nanotechnologies aux Etats-Unis – Histoire, bilan et perspectives du programme National Nanotechnology Initiative*, Vincent Reillon, Rapport d'Ambassade de France à Washington, Agence pour la Diffusion de l'Information Technologique, avril 2011.

The roadmap for the next ten years has designated energy as the principal field, along with health care, electronics and national defense. **Cooperation is being developed in the field of neurosciences and new energies.** Mass-producing standardized nanomaterials in a responsible way is the challenge for 2020 (see Appendix 4: United States, Appendix 1).

IV.7.c Priority Sectors

Nanoscience's bear the promise of radical transformation in many areas: energy, health care, information technology, material sciences. The great challenges listed by the NNI are:

- Nanostructured materials by design;
- Nanoelectronics, optoelectronics and magnetism; Advanced medical care: Therapeutic and diagnosis;
- Improvement of the environment;Energy conversion and efficient storage;
- Space exploration;
- Biosensors for therapies and detection of biological threats;
- Economical and safe transportation; Nano-systems (nano-robots, NAVs[56]: Nano Air Vehicle);
- National security.

Figure 36 shows the evolution of the budget dedicated to the NNI for the main agencies. The 4 NNI topmost agencies are: DoD, NSF, DoE and NIH, accounting for 90% of the budget by themselves. The DoE budget is still growing strongly, the energy being a priority of the Obama administration. NASA'S budget was relatively high from 2001 to 2006; although budgets have been increasing again, they have not reached to their previous level.

See Appendix 4: United States, Appendix 2

[56] *Nano Air Vehicles, a Technology Forecast*, William A. Davis, Major, USAF, Center for Strategy and Technology, Air War College, April 2007.

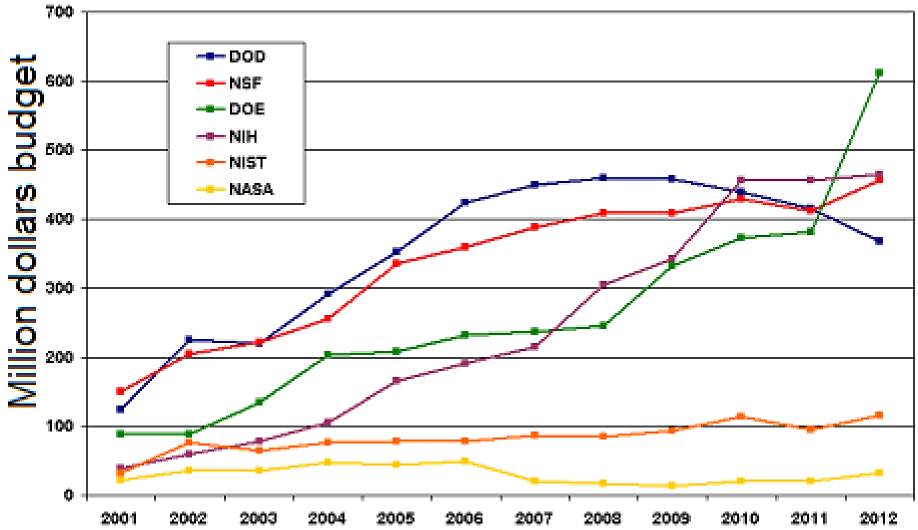

Figure 36. Evolution of federal agencies NNI Budget per fiscal year.

IV.7.d Defense and security-related programs

Generally speaking, nanotechnologies may revolutionize technologies in the areas related to from materials science: catalysis, transistors and computer memories, biomedical, energy conversion and storage, water filtration, video display, coatings, etc. Among all these applications, some have more immediate strategic interests and are classified as priority in the US, according to the following items. **Defense and national security is an ongoing priority for the USA.** DoD has long been the largest recipient of NNI funding. DoD interests are so broad that all potential applications of nanomaterials in the fields of energy, electronics and health may be of interest. The DoD is also focusing its research on developing new multifunctional materials: lighter, more resistant and durable, capable of self-repairing, requiring less power or which may be self-powered. Nanotechnology must still be considered in its infancy in terms of technology and engineering[57].

To control the use of nanotechnology, in all sectors, **development of simulations** is undertaken and is considered a key transverse technology.

Founded in 2002, the Institute for Soldier Nanotechnologies (ISN), funded by the US Army and designed to leverage the unique capabilities of the US military, is an example of nanotechnology initiative between Government and Universities. Its mission is to drastically improve soldier survivability through nanotechnology, using basic research and technology transfers to the military and industrial partners. Improvements may include: reducing the weight carried by soldiers, improving ballistic protection, the creation of new detection and detoxification methods for chemical and biological threats, and also ensuring physiological monitoring and automating medical intervention. The ultimate goal is to help the Army to create an integrated system of nanotechnology for soldier protection.

[57] *Defense Nanotechnology Research and Development Program*, Department of Defense, December 2009.

NNI 2011-2020 Strategic Plan

All policies listed above are found in the NNI Strategic Plan published in February 2011[58], and in the EHS strategy[59] update. With respect to nanomaterials manufacture, solar energy conversion and Nano electronics, the work plan has been defined in detail (Signature Initiatives)[60]. NNI is planning to launch five more such initiatives in the next five years. Responsible development and societal issues will be emphasized, addressing the need for exchange and communication, and encouraging vocations to ensure development of a skilled workforce for the future. The flagship of the new strategy is control of nanomaterials and products life cycle; this issue has been integrated in all research projects. The new strategy also includes ethical, legal and social implications as essential components in the pursuit of responsible development of the field, emphasizing the importance of communicating the potential risks to all stakeholders (public, workers, etc.) to advance awareness of the importance of these issues.

Six main areas have been identified:

- "Nanomaterial Measurement Infrastructure". Metrology, measuring instruments, instruments of detections or the protocols and references are essential tools which, for the moment, starved in the field of nanotechnology.
- Characterization of human exposure to nanomaterials is the second field. The third field concerns human health.
- The environment is the fourth field.
- The fifth field includes risk evaluation and management methods.
- A sixth field was added: IT, a new field compared to the 2008 strategy, a wide field transverse to all issues. Researchers and agencies need to be able to quickly share information and simulation models through creation of an infrastructure common to all agencies, control of data, protocol and reference quality as well as format of accumulated data. Computer simulation would then be, over the long term, the only way to correctly estimate the overall risks posed by a given nanomaterial. This would lead to more cooperation and collaboration between the different actors and disciplines, and ensure acceleration of the pace of progress. Faced with these challenges, an action and coordination strategy is more necessary than ever.

Support to technology transfer and commercialization of products is a priority, to transform research promises. Otherwise, US voices clamoring for stopping costly research with few results may become more numerous and popular. Getting to responsibly mass-produce standardized nanomaterials, thus promises to be the challenge for 2020.

Since the launch of the nanotechnology program, it has always been clear in the USA that the

[58] *NNI strategic plan 2011*, NSET, février 2011. – http://www.nano.gov/html/res/nnistrategicplan211.pdf
[59] NNI 2011 EHS Strategy (Draft), NSET, 6 December 2010.
http://strategy.nano.gov/wp/wpcontent/uploads/2010/12/DraftEHSstrategy-17Dec2010-to-post.pdf
[60] The first three Signature Initiatives – http://www.nano.gov/html/research/signature_initiatives.html

investment made through NNI is for the long term, for a minimum of 20 years[61]. Based on their experience and success, the United States are entering the program second decade, confident of keeping their nanotechnology leadership for at least several years. DoD will continue to coordinate its nanotechnology programs, which include DARPA and other federal agencies. While nanotechnology basic research continues to mature, DoD anticipates that expected results of applied research efforts will lead to development of advanced military technologies. The DoD nanotechnology program remains robust and well balanced to enhance Defense potential[14].

The DOJ National Institute of Justice (NIJ) has also two programs[62] involving nanotechnology. Development of DNA forensic research device is taking place in basic research. Another project involves development of a quick, portable and low cost device to warn of exposure to unexpected chemical and biological risks with sufficient response time to ensure effective protection.

Legal issues

The use of nanomaterials in commercial products is growing faster than the understanding of the risks these materials pose for human health and the environment. Gao (US Government Accountability Office) has listed commercial nanotechnology applications[63] and found EPA (Environmental Protection Agency) information to be deficient. The EPA requires chemical companies to periodically provide information on several currently available chemicals. However, the EPA has not extended this requirement to nanomaterials, and is asked to address this issue through the Clean Water Act to regulate this area.

[61] MIHAIL C. ROCO, *Nanotechnology Research Directions for Societal Needs in 2020*, Spinger, October 2010.

[62] *National Nanotechnology Investment in the FY 2010 Budget*, M. C. Roco, American Society of Mechanical Engineers.

[63] *Nanomaterials Are Widely Used in Commerce, but EPA Faces Challenges in Regulating Risk*, Government Accountability Office, Committee on Environment and Public Works, U.S. Senate, mai 2010.

IV.7.e Evolution of number of patents

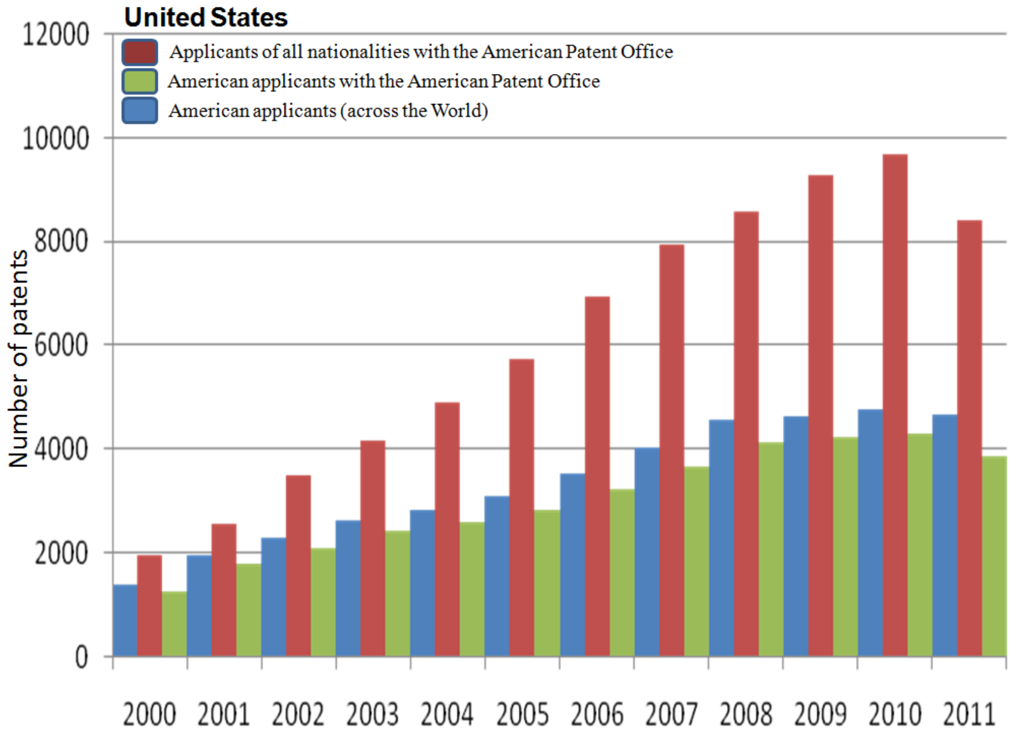

Figure 37. Patents published in the US between 2000 and 2011.

The United States ranks second in terms of number of patent published. The number of patents has grown steadily between 2000 and 2010 (Figure 37).

IV.7.f Types of companies

USA on the world stage

Collaboration in the R&D sector

International cooperation between universities, research centers, institutes and industries (SMEs / SMIs, large groups) have developed in different areas with all global players, like in other sectors of American industry. Nanotechnologies are no exception to this. Figure 38 shows that DoD will continue to rely on a purchasing strategy and business partnerships to extend its expertise in nanotechnology, and intervene only in case of overriding imperatives.

Existing Product	Army Application
Paints and coatings	Paints and coatings
Cutting tools and coatings	Wear reduction
Sunscreens and cosmetics	Protective cosmetics
Burn and wound dressings	Burn and wound dressings
Catalytic converters	CB decontamination
Synthetic fuels and energy	Synthetic fuels and energy

Figure 38. Commercialized Nanotechnology with Potential Army Applications .

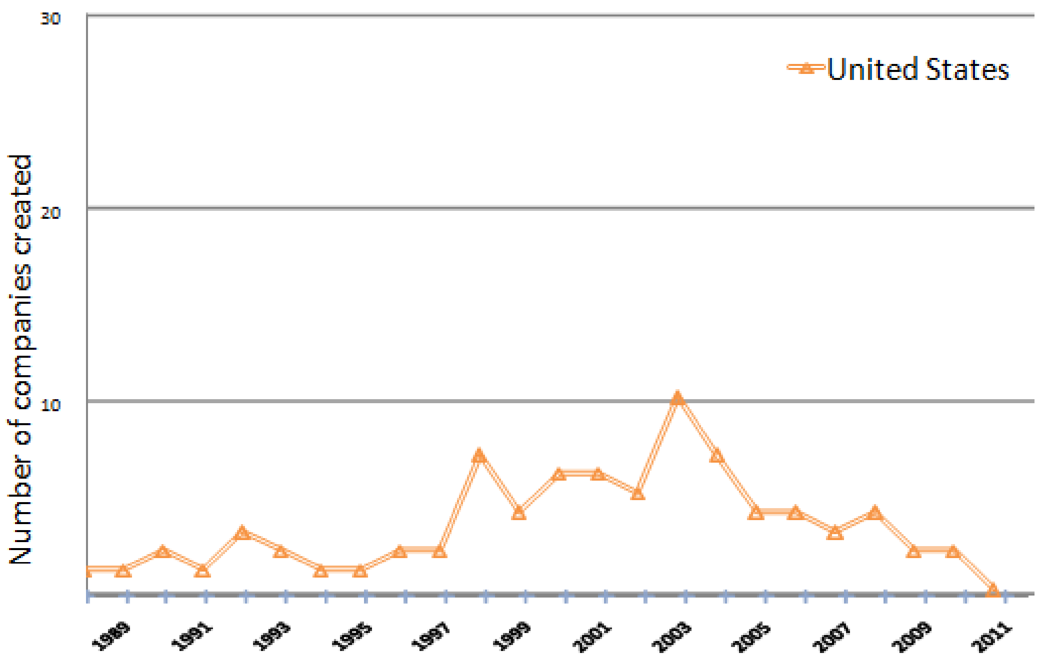

Figure 39. Creation of 80 nanotechnology companies in United States from 1989 to 2011 (only 1/10th of companies were sample).

With 1164 companies listed, the United States ranks first in terms among the 13 countries in this study. Only 1 / 10th of companies were sampled for this chart (119 were analyzed by way of random sampling).

The chart (Figure 39) shows that activity started in 1980, followed by a second peak in 1985. But the real start began in 1998. From then on, and until 2005, the number of company creations was important and relatively constant (peaking in 2003). Since 2006, the number of companies created has dropped sharply, despite increasing government investment over the past decade. Figures 41 and 42 show how these companies are distributed by sector.

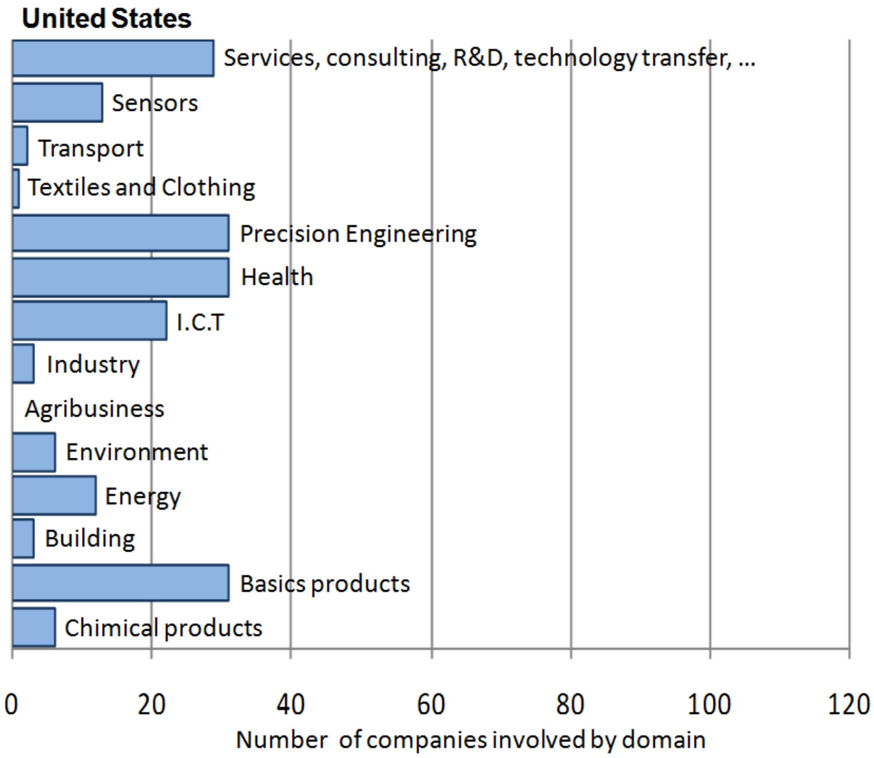

Figure 40. Distribution of 119 U.S. companies as sampled.

With respect to **health**, research (which is necessarily dual), is moving in two directions: On the one hand, toward improving diagnoses and, on the second hand, toward developing targeted therapeutics, in particular to treat cancer. The aim is to develop personalized medicine which would take the genetic data of the individual into account to strengthen prevention and to develop the most appropriate treatment. *In-silico* methodology has become unavoidable, in addition to traditional *in-vitro* and *in-vivo* toxicology methods. Biochemical events taking place at the nanoscale require a better understanding of biological phenomena, but also give the opportunity to interact directly with them for optimal use of materials that can perform a function at this scale: nano-markers, diagnosis, targeting cells to destroy them selectively, and ensuring that interactions of nanomaterials with biological environment pose no risks. One other key objective is the development of rapid and economical DNA sequencing methods; nanotechnology should revolutionize this field soon [64]. It is therefore logical that the United States are strongly positioned in the medical field and the field of sensors.

With respect to **energy issues**, nanotechnology may achieve a major dream for the USA: independence. For the moment, the country - whose population represents just 5% of the world population - produces 15%, but consumes 21% of the world energy. 83% of the consumed energy is of fossil origin (oil and gas). Also, 57% of that energy is lost (low yields of fossil energy transformation into electrical energy, for example). Energy dependence is clearly an obstacle to development, especially when resources are subject to high geopolitical tensions. Physics show that all energy conversions are nanoscale, thus

[64] V. REILLON, *Les nanotechnologies pourraient assurer un séquençage de l'ADN rapide et économique*, BE Etats-Unis 217, septembre 2010.

nanotechnology may bring revolutionary applications in energy production and storage. The most promising option is solar energy. It is an abundant resource and the United States have extensive non-agricultural tracts of land to develop solar power plants. Research is undertaken in two main directions: production of electricity and artificial photosynthesis, requiring developments in energy storage. It is therefore natural that energy is a strong point of the United States.

Other main strengths of this country are: Raw materials, Environment, Information Technologies and Communication, Precision mechanics and sensors. The United States has also R&D and production capabilities. Many corporations display military applications on their websites.

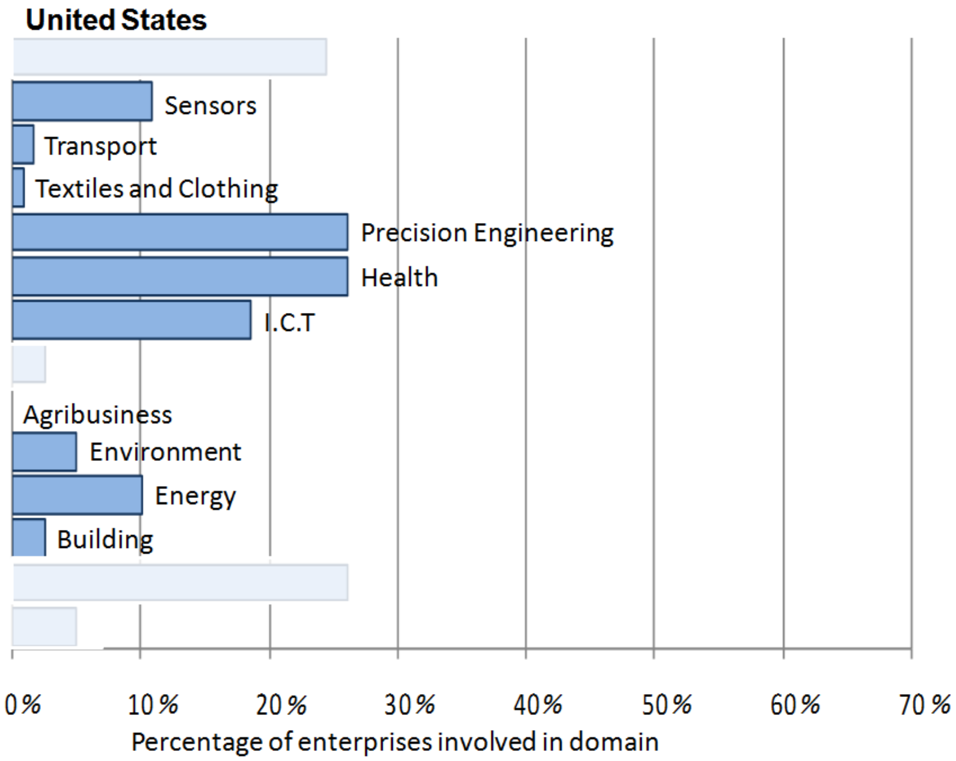

Figure 41. Distribution of U.S. companies (%).

Conclusion

Through the National Nanotechnology Initiative, the largest US program since the space program, the United States are leaders in the field of nanotechnology. Major issues under development are Nano electronics, the environment, energy conversion and storage, development of nano-systems, and medicine, of which a main objective is development of rapid and economical DNA sequencing methods, a field that nanotechnology should revolutionize soon[65]. There is also a very substantial investment in terms of simulation, considered to be transverse technology, which should eventually enable the risks associated with the use of nanotechnology to be assessed.

That country also strives, through metrology in particular, to define a set of standards and protocols designed for data exchange between researchers, but also to protect individuals and the environment.

The United States is the country that has funded most heavily the development of nanotechnology, which also benefits from substantial private funding. A large number of patents is filed in the USA, which have been able to build the world's largest industrial base. Another advantage of the country is the a large number of venture capitalists (see Appendix 4, Appendix 3). Support to technology transfer and commercialization of products is a national priority.

[65] V. REILLON, *Les nanotechnologies pourraient assurer un séquençage de l'ADN rapide et économique*, BE Etats-Unis 217, septembre 2010.

IV.8 India

IV.8.a Master data

Population (2012)	1.2 billion
Area	3.3 million sq. km
Average Density	382 residents/sq. km
GDP (2011)	$ 1,833 billion
GDP/capital (2012)	$ 1,530
HDI (2012)	0.55

IV.8.b India's efforts

There is in India a strong government will to develop nanotechnology and establish research structures in the field.

In the late 90s, aware of nanotechnology importance for the future and of the country assets (skilled workforce and low cost), the Indian government created three agencies with a mission ensure promoting and developing nanotechnology R & D:

- Department of Scientific and Industrial Research
- Department of Biotechnology
- Department of Science and Technology (DST); this agency plays a predominant role.

En 2001, a Nanoscience and Technology Initiative was entrusted to DST, chaired by Pr. C.N.R. Rao, with making India a major player in the field as the target. It received a USD 15 million budget for years..

DSR has implemented a hundred research projects, distributed among the country research institutes; there are ten nanoscience teams, in six centers dedicated to nanotechnology and one dedicated to high power computing.

The concept of "Nanotechnology Cluster" appeared, designed to combine through collaborations developed between institutes the skills necessary for projects on topics such as development and control of thin films, Nano sensors, nanobiotechnology, superconductivity, and "micro" and "nano" manufacturing processes.

In 2007, the Indian Government again showed its political will to make progress in the field of nanotechnology, and started a new government initiative supported by $ 250 million funding. Establishment of a tripartite governance comprising representatives of the State (DST), of scientists and industry representatives was designed to develop strategic partnerships between industry and research institutions.

Twenty large institutions are currently involved in R&D programs, which include the *Indian Institute of Science*, the *Jawaharial Nehru Center for Advanced Scientific Research*, universities like *Anna University*, the *University of Delhi*, defense agencies such as the

Defense Research and Development Organization (DRDO), and also research laboratories based in foreign countries (joint research Centre with Canada, etc.).

A major training effort for researcher and engineer training is under way, and many institutions offer courses and exchanges with foreign countries. Career opportunities seem available to them, in keeping with research and industrial applications which thrive in the energy, aeronautics and space, the environment, telecommunications, information technology, health and biotechnology sectors.

Based on the financial volume of such activities, India ranked 10th on a world basis in 2010 (ref. Cientifica), consistent with its GDP ranking. Some observers claim significant nanotechnology growth, and even forecast sales of USD one billion by 2015.

From our perspective, such growth would require that the industry develops its ability to commercialize the results of research well beyond what exists today, when the industry mainly consists of small, start-up type structures, whose annual sales very rarely exceed USD one million.

The number of nanotechnology publications has increased significantly in India, starting in 2000s (Figures 42 et 43).

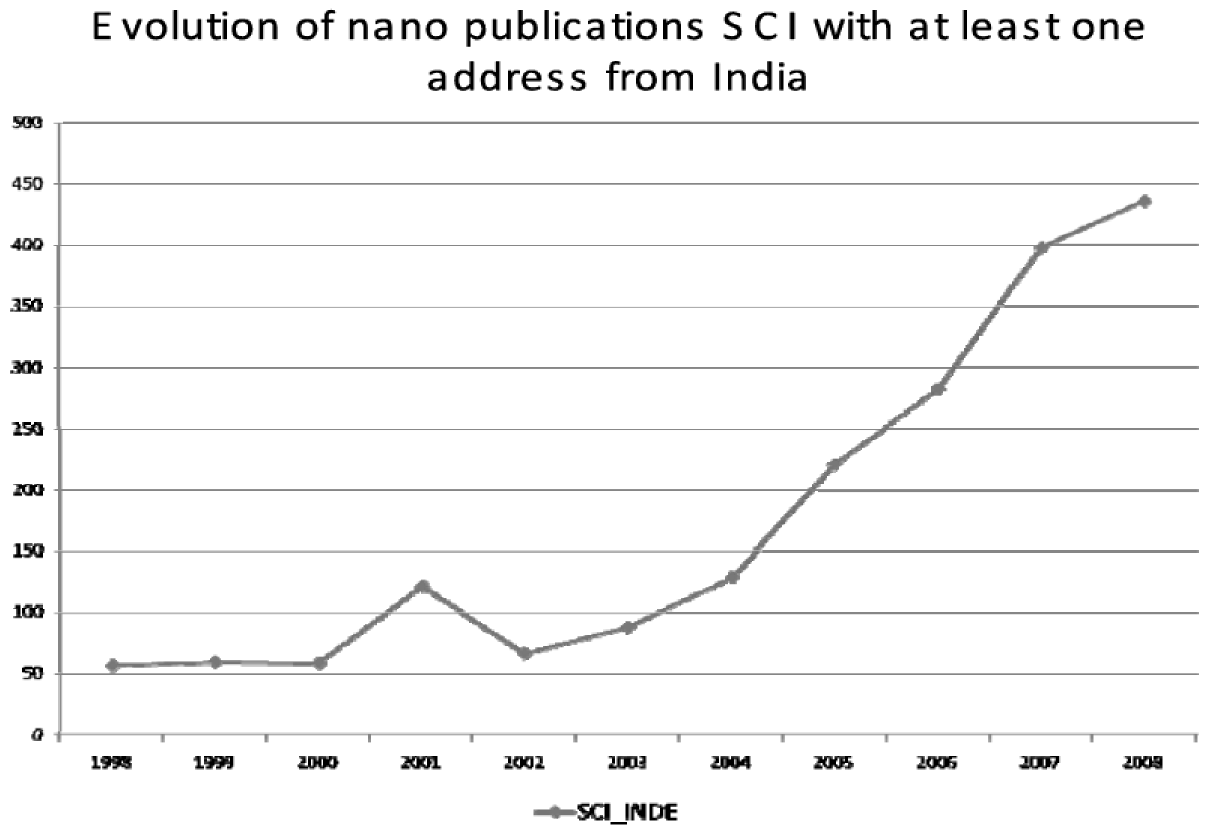

Figure 42. Evolution of publications with at least one author being a citizen India.
Source: United Nations University, report #2011-020.

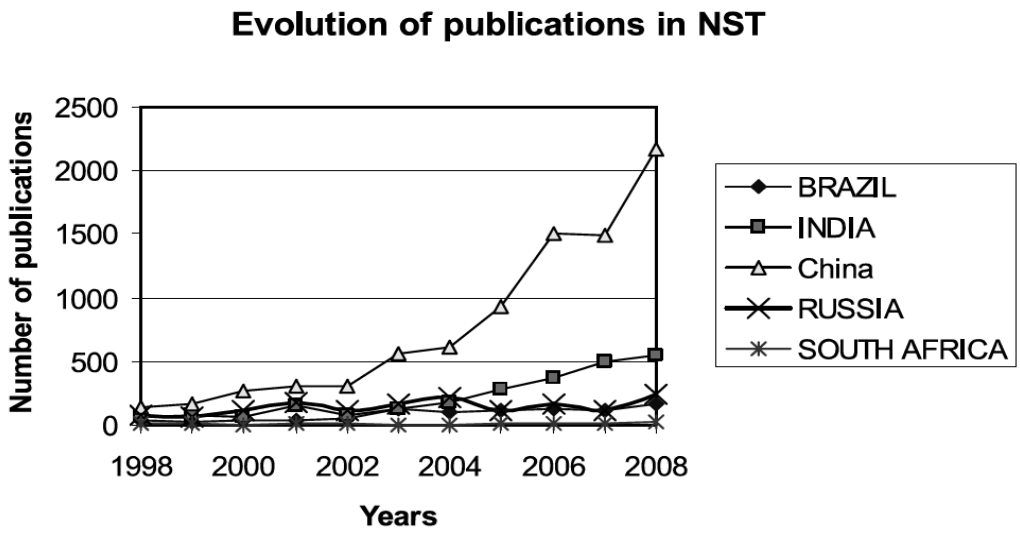

Figure 43. Evolution of NST publications in India and others BRICS from 1998 to 2008.
Source: United Nations University,

IV.8.c Priority areas

Research works on nanomaterials are subject to a large number of publications, which reflects priorities and attractiveness for researchers. A significant part of patents are filed with respect to nano-catalysts and nano-polymers, which are strategic economic points for the control of industrial processes (Figure 44).

Many companies, often subsidiaries of US companies, are active in the field of manufacture of nanomaterials as well as in biotechnology.

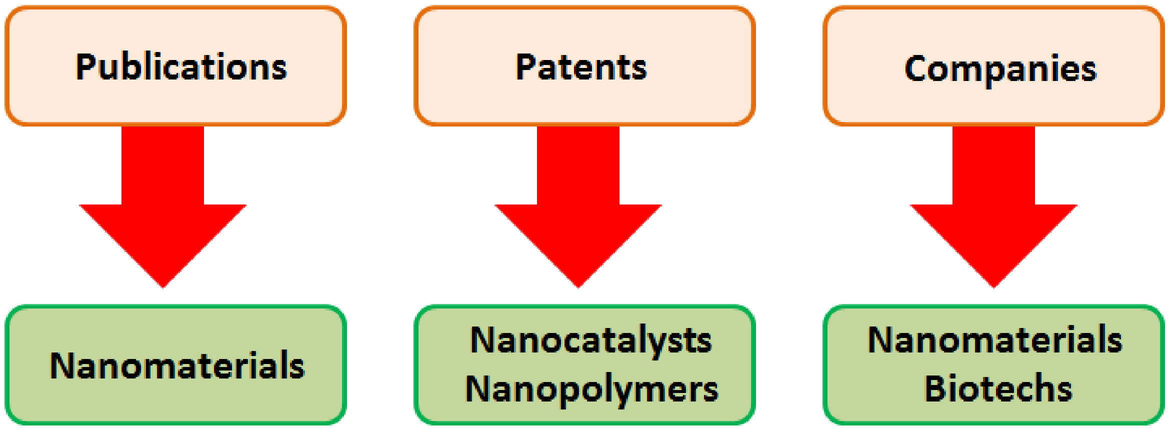

Figure 44. Priority areas.

IV.8.d Evolution of patents Number

Figure 45 shows the evolution of the number of patents filed between 2000 and 2011.

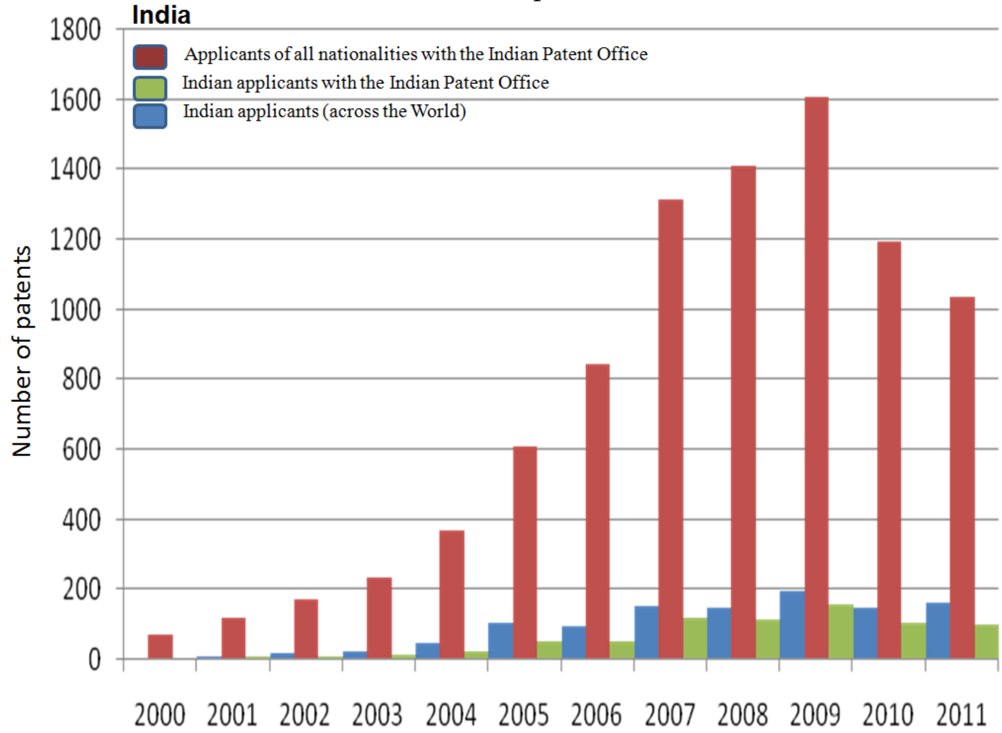

Figure 45. Patents published in India between 2000 and 2011.

IV.8.e Types of companies

The number of nanotechnology companies created annually in India is low, as shown in Figure 46.

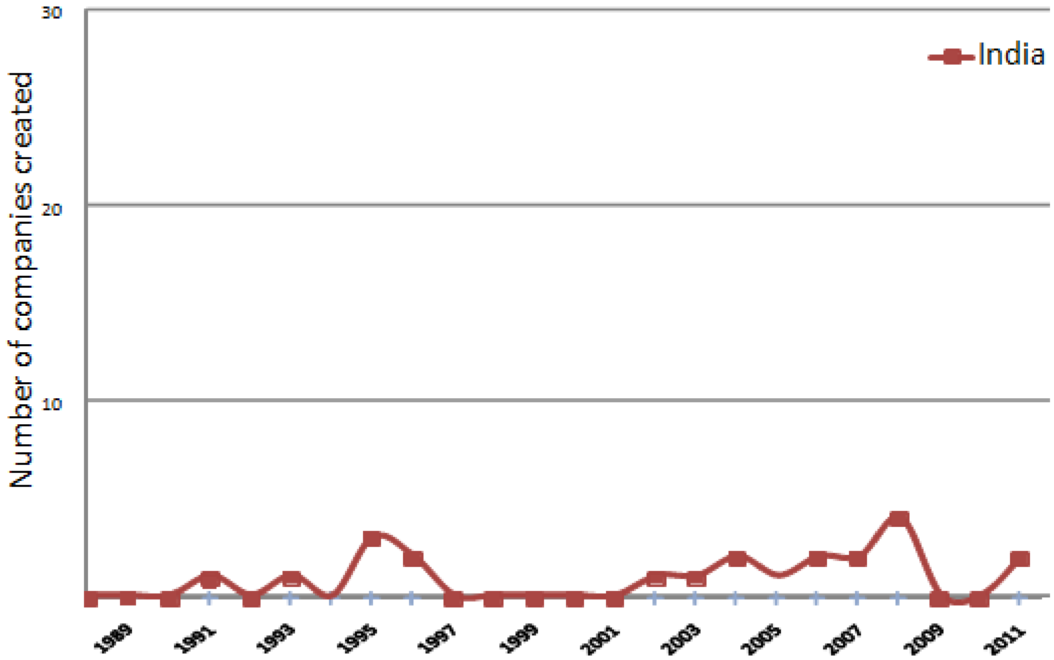

Figure 46. Creation of 22 nanotechnology companies in India from 1988 to 2011.

The total number of companies in this study is 29, 22 of which were created between 1988 and 2011. It shows only two small peaks, in 1995 and 2008.

Figure 48 shows the areas of activities of these 29 Indian companies

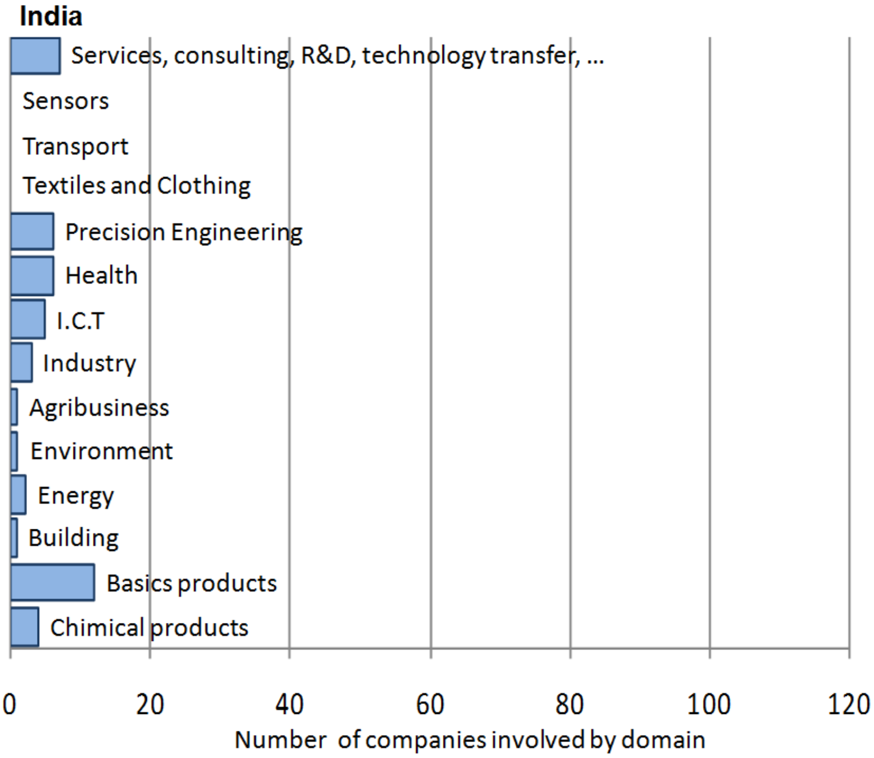

Figure 47. Distribution of the 29 Indian companies identified.

Both R&D and industrial production capabilities of these companies show that "commodities', closely linked to the materials, are important. There are no companies in the fields of textiles and clothing, transportation and sensors.

Figure 48 shows the distribution (in percent) of the 29 companies in the 10 areas identified as potentially related to military and / or security applications.

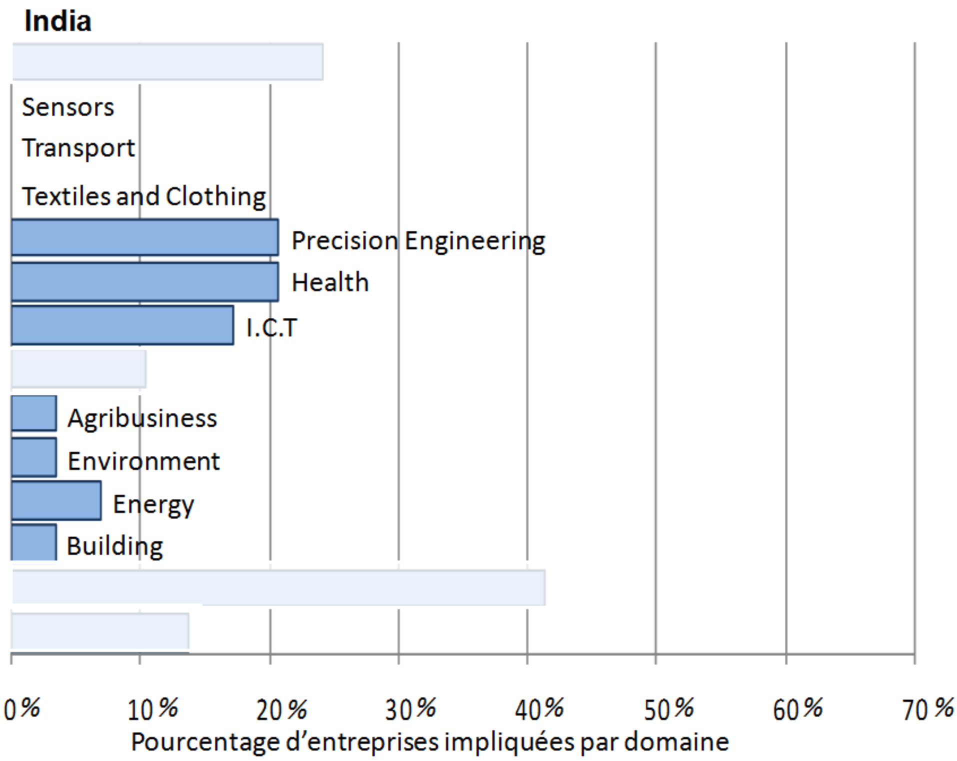

Figure 48. Distribution of Indian Companies in the 10 areas of interest (%).

Based on these criteria[66], no strong ability emerges; however medicine, precision engineering, information and communication technologies, and energy are at an intermediate level.

[66] See Section 1.1.3 of this report.

Conclusion

Recognizing importance of nanotechnology for the future, India set up, in the late 1990s, three agencies whose mission was to promote and develop nanotechnology R&D. Fields chosen are: development and control of thin films, nano-sensors, nano-biotechnology, superconductivity, as well as micro and nano fabrication processes, including nano-catalysts and nano-polymers.

A major training effort for researcher and engineer training is under way, and many institutions offer courses and exchanges with foreign countries, in particular with Canada. Career opportunities seem available to them, in keeping with research and industrial applications which thrive in the energy, aeronautics and space, the environment, telecommunications, information technology, health and biotechnology sectors. As a result, this number of publications has increased significantly.

While the industrial structure of India currently consists mainly of small, start-up type, companies whose annual turnover rarely exceeds USD one million, the rapid development of India could lead this country to quickly catch up in the field of nanotechnology.

IV.9 Indonesia

IV.9.a Master data

Population (2011)	245 millions
Area	1.9 million sq. km
Average population density	130 residents/sq. km
GDP (2011)	$ 700 billion
GDP/inhabitant	$ 2,900
HDI (2011)	0.62

IV.8.b Indonesia's efforts

Nanoscience's and nanotechnologies (NST) Programs in the Republic of Indonesia

Indonesia, the 4th most populous country in the world and the country with the largest predominantly Muslim population, is a democratic republic whose standard of living is very low (GDP/capita ranked 150th in the world), despite an active investment policy, and an economic growth which has not reached levels comparable to that of neighboring countries (China and India).

This developing country status explains why Indonesia has remained behind in terms of advanced technologies.

Interest in NST is relatively recent: in 2005, the government recognized how important NST are in terms of research, and decided to invest.

A USD 27 million fund was created, to finance some sixty research projects based in universities and research centers. The Indonesian Society for Nanotechnology (INM) manages these projects and grants scholarships for young people to study NST.

Fields of interest are primarily food (need to improve food supply), energy (search for alternative energy because of limited natural resources), health care (in particular treatment of tropical diseases), the environment (monitoring of land, sea and airspace) and transportation (whose importance stems from the vast expanse of the archipelago).

A few manufacturers, including *Mochtar Riady Center for Nanotechnology and Bio-engineering* (MRCNB) are also involved in financing research projects, but we have no recent information on the current status of these, nor on any industrial spinoffs.

Indonesia on the worldwide stage

An international symposium was held in 2011 in Bali: *The 4th Nanoscience and Nanotechnology Symposium*.

Several cooperation agreements are in force:

- With Egypt,
- With France (Nusantura 2011 program),
- With Iran (through the *Organization of the Islamic Conference Network on Nanotechnology*, of which Indonesia is a member. This network organizes many seminars about NST in Tehran).Indonesia is also a member of the Asian Forum on Nanotechnology (ANF), a collaborative platform for development and promotion of NST.

IV.8.c Evolution of number of patents

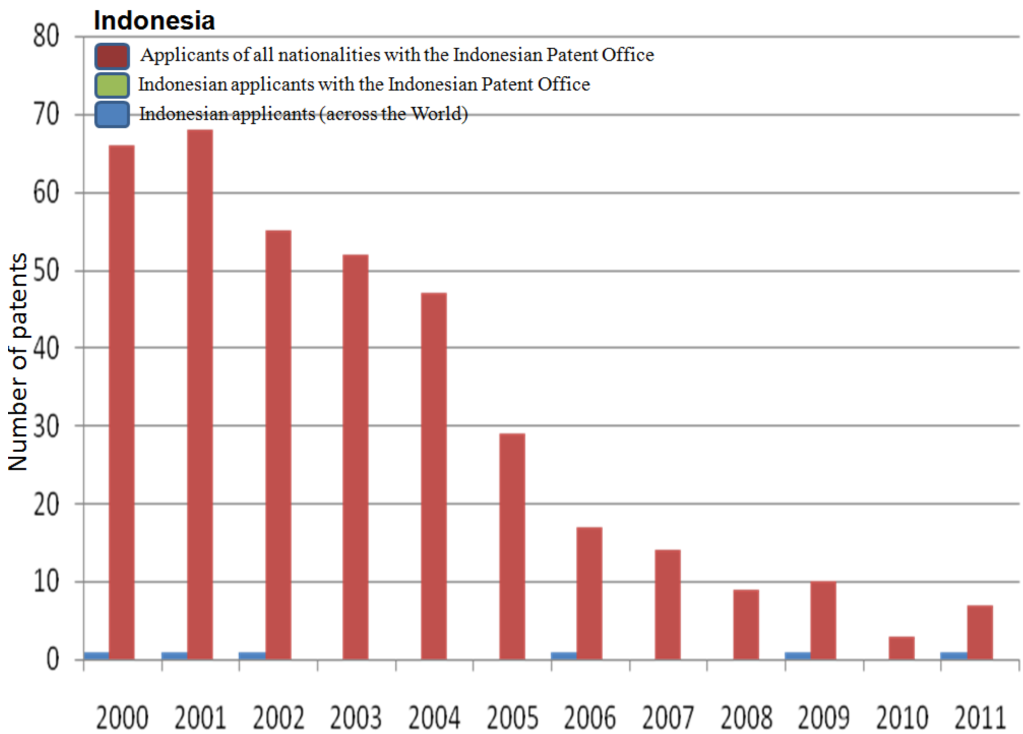

Figure 49. Patents published in Indonesia between 2000 and 2011.

It is notable that almost no patents are filed by Indonesian nationals (Figure 49).

Conclusion

Involvement of Indonesia with NST currently remains very modest, due obviously to limited funding capacity and to the country development. Conventions are organized under the umbrella of Muslim countries; this is a source of exchange. Fewer and fewer patent are filed by foreigners.

IV.10 Israel

IV.10.a Master data

Population (2011)	7 millions
Area	20,000 sq. km
Average population density	367 residents/sq. km
GDP (2011)	$ 217 billion
GDP/inhabitant (2010)	$ 28,685
HDI (2010)	0.888

IV.10.b Measures and actions

Nanoscience and nanotechnology (NST) programs

Nanotechnologies have been defined as strategic for Israel, and they receive financial support from US institutions Israeli defense-oriented SMEs and major companies are not shy about their defense applications, in particular those including nanotechnology.

The dynamism of Israeli NST laboratories can be measured by number of publications and patents, and by commercial success of Israeli companies. To enhance the efforts of researchers and to maintain a reputation recognized worldwide, Israel has policies and financial means: At first, the Nanotechnology National Committee[67] was created to assess this sector, and several five-year development and funding programs (2007-2011, 2012-2016) were implemented, to male nanotechnology one of the spearheads of Israeli science. In fact, a first nanotechnology program took place from 2003 to 2007, but it has been barely described or mentioned. Over the past 10 years, more than USD 250 million have been invested in infrastructure and research equipment.

The business model implemented is built on a "*Funding triangle donation matching program"* model: universities, private donations, government, each contributing one third of the financing (similar to the German business model). This is an excellent example of the use of public funds, and it provides a very good return on investment.

Analysis of the Israeli government shows that all departments collaborate strongly in the matter. Officially, several Israeli government-controlled centralizing agencies, and the Nanotechnology Committee, have been established:

- INNI (*Israel National Nanotechnology Initiative*), created in 2001 to set up collaborations

[67] Nanotechnology National Committee, appointed in 2000 by the Israeli TELEM coordination group, composed by: Binyamin Netanahu Prime Minister, Minister of Economic Strategy, Minister of Health, Mr Yaalon Deputy Prime Minister and Minister of Strategic Affairs, Deputy Prime Minister, Minister of Regional Development of the Negev and Galilee, 1st Deputy Minister and Minister of Defence, D. Meridor 1st Deputy Minister and Minister of intelligence and atomic Energy, the Minister of Science and Technology, the Minister of Industry, Trade and Employment, the Minister for national Infrastructure, the Minister of Civil Defence, Minister for the Environment, the Vice-Minister of Finance, Deputy Minister of Health.

between industry, science and academia, and ambitious long-term research and development programs, as well as investment and infrastructure to be among best in the world.

- MATIMOP, created in 2006, is the operational framework agency of the OCS (*Office of the Chief Scientist*) of the *Ministry of Industry, Trade and Labour* (MOITAL). Matimop is the Israeli agency for R&D/industry cooperation, responsible for strong promotion and support policies to build Israel's industrial infrastructure, and to strengthen industrial innovation and entrepreneurship. This agency initiates and develops international R & D cooperation between Israel and foreign companies.

Key actors:

- Academic Institutions: Israel hosts six research institutes/universities which are among the best in the world; each of them has its own advanced programs in nanoscience, focused on a specific discipline and research and its own internal methods: *Bar Ilan University* (*Bar Ilan Center for Advanced Materials and Nanotechnology*, mostly defense applications), *Technion Israel Institute* (*Russell Berrie Nanotechnology Institute-RBNI*), *Tel Aviv University Research Institute for Nanoscience and Nanotechnology*, *Ben Gurion University of the Negev*, *Weizmann Institute of Science, Hebrew University of Jerusalem*.Nanotechnology start-ups: In 2007, Israel had the third largest concentration of start-ups in the world.Companies: Israel has identified the crucial role of industry to move nanotechnology to common and widespread use, e.g. *Elbit*, *Plasan Sasa-Raphael*, *Plassan*, *Israel Aircraft Industries,* etc.Venture Capital Investors: Israel is ranked among the coutries which most use foreign venture capital and business angels.

Comments:

- Key technology companies maintain active R&D centers in Israel. Global economic surveys rank Israel among the most attractive nations for developing advanced technologies.
- The Israeli labor market is among the most skilled in the world: 20% of the workforce has a university degree. For 10,000 employees, 140 have a science or technology degree, and 135 an engineering degree. Similar ratios are much lower in the USA, Japan and Europe.

In 2007, Israel established the nanoscience sector as a priority national project, to create the research infrastructure with six universities which supports companies in this field. The thematic distribution of 618 Israeli scholars in the field of nanotechnology is as follows:

- Environment and Energy: 22
- Nanotechnology general sciences: 15
- Materials and Interfaces: 158
- Nanotechnology & Nanomedicine: 153
- Nanochemistry: 41
- Nanomaterials and Nanoparticles: 91
- Optics and Photonics: 96
- Other: 42

In addition to these academic researchers, there are 320 junior scientists / postdocs, 816 doctoral students and 915 master's student (September 2011 Figures). This translates into

625 industry / academia collaborations, 185 active patents, 704 patents pending, 171 success stories (spin-offs having implemented patent licenses), and 6067 scientific articles published, of which 1171 resulting from industry collaborations with Israeli academia. Based on population, Israel ranks second worldwide for publications, and third for patents.

Since this program was established by the Israeli government, 88 scientists, among the best in the world, have immigrated to Israel where they work at 6 major universities.

IV.10.c Priority areas

The tradition of scientific excellence in Israel is widely appreciated worldwide, and Israeli technological advances are at the forefront of the communications, electronics, software, networking, defense, security and life science industries.

During the first five-year nanotechnology development plan, priorities for academic research had focused on developing nanomaterials, nanobiology and Nano electronics, as well as some interesting niches such as biological sensors (including those designed for unconventional and terrorist attacks), detection of narcotics and vaccines, targeted drug action, optical switches, fast laser telecommunications, biocompatible surfaces, gene therapy, laboratories on chips, active filters and nano catalysis. In addition, applications in energy and water desalination were added to technology priorities.

Figure 50 shows, for recent years (post 2010), distribution of the main themes studied in Israel: Nano-bio and nano-medicine, Nano electronics and nano-optics, Nanomaterials, Nano-water.

Discipline	Applications of Nano-Related Research	Level of Activity
Nanobio and Nanomedical Science	*Bio*–Biosensors, new biotechnologies for synthesis and analysis; functionality detection; molecular computing; molecular electronics; nanoscale arrays; integrated bio-chips (integrating Nano and MEMS). *Medical science*–Field sensor and detoxification for nerve gas and viruses; novel drug therapies, including gene therapy and peptide and protein delivery systems; detoxification of blood via interaction with nanoparticles; selective treatment and smart medicines; drug or vaccine release.	Current research in the bio/medical area is increasingly likely to be commercialized and marketed. Nanobiotech capacity benefits from growing dedicated pools of venture funding.
Nanoelectronics and Nano-Optics	Higher-speed devices; high-density low-cost arrays; denser and faster low currents and electronics with larger memories; sensors; and SI-based lasers. Integrated optoelectronics on Si chips; tunable LEDs and lasers; optical switches and logic gates; infrared detectors; optics based on nanostructures.	More than 80 percent of Israel's nanotech researchers are engaged in disciplines that contribute to nanoelectronics and photonics.
Nanomaterials	Produced through chemical processing, harder, self-repairing, and environmentally friendly materials; novel coatings that are super-hard and wear-resistant; novel thin films with unique properties such as high magnetization and improved adhesion; high-performance nanocomposites, super-lubricants, and high-performance smart ceramics.	Among the nano-related disciplines, Israeli chemistry nanoresearch is currently funded at the second highest level, after basic scientific research.
Nanowater	Nanomembranes, nanofiltration, and other nanotechnologies used in water remediation. Applications in water treatment and alternative energy.	Israel's filtration and membrane R&D remains strong, with a national research capacity exceeding that of many larger nations.

Figure 50. Israel's Nanotech Priority Areas and Applications .

Israel on the worldwide stage

Collaboration in R&D

Israel naturally cooperates with countries with excellent scientific developments and technology, i.e., in this order: USA, Germany, Russia, India, Singapore, China and France. For example, 50% of nanotechnology patents in Europe are German; Israel's cooperation with Germany (including the *Fraunhofer Institutes*) is much farther ahead than with France, because of its technological lead.

This results in creating R&D partnership, opening of branches, or even equity investment in Israeli companies by foreign SMEs or big companies.

Israel also performs business intelligence of emerging or sensitive countries, or countries with business potential. Scientific and commercial relations have been established with, for example, Iran, South Africa, Brazil, etc.

In May 2010, Israel became an OECD member. Israel is the only country outside the European Union to take part in European R & D programs. Strong nanotechnology partnerships have been established between Israel and companies such as *Intel*, *Merck KgaA*, *Siemens*, *Bayer*, *Arkema*, etc.

Israel has entered into 30 binational technological development agreements with the USA, the UK, the EU, Russia, China, India, Japan and others, as well as free trade agreements with the USA, Canada, the EU, Mexico, Turkey, Jordan, Egypt, Romania, Bulgaria and the Mercosur block.

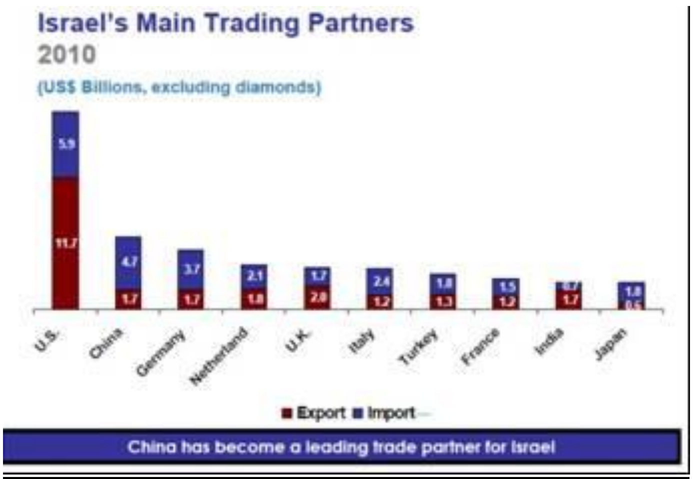

Figure 51. Israel's Main Trading Partners .

IV.10.d Evolution of number of patents

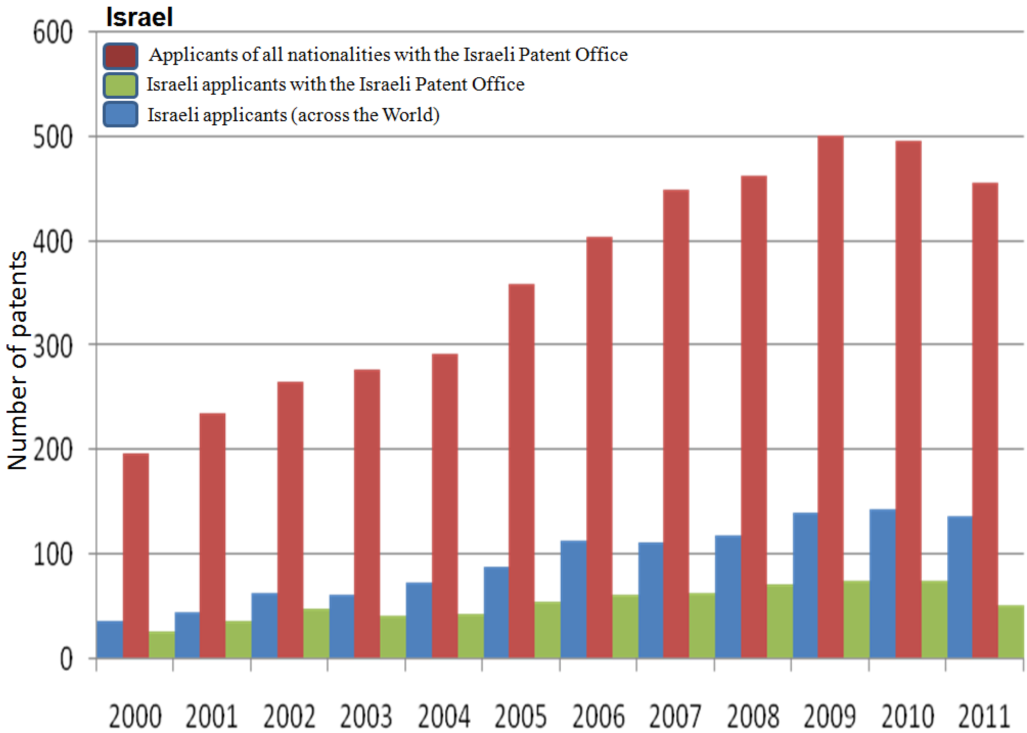

Figure 52. Patents published in Israel between 2000 and 2011.

In terms of number of patents, Israel ranks 11th among the 13 countries in this study. The difference in the number of patents filed by Israeli and other nationalities is significant (Figure 52). While the overall number of patents filed between 2000 and 2010 increased, patents filed by Israelis increased only very slightly.

IV.10.e Types of companies

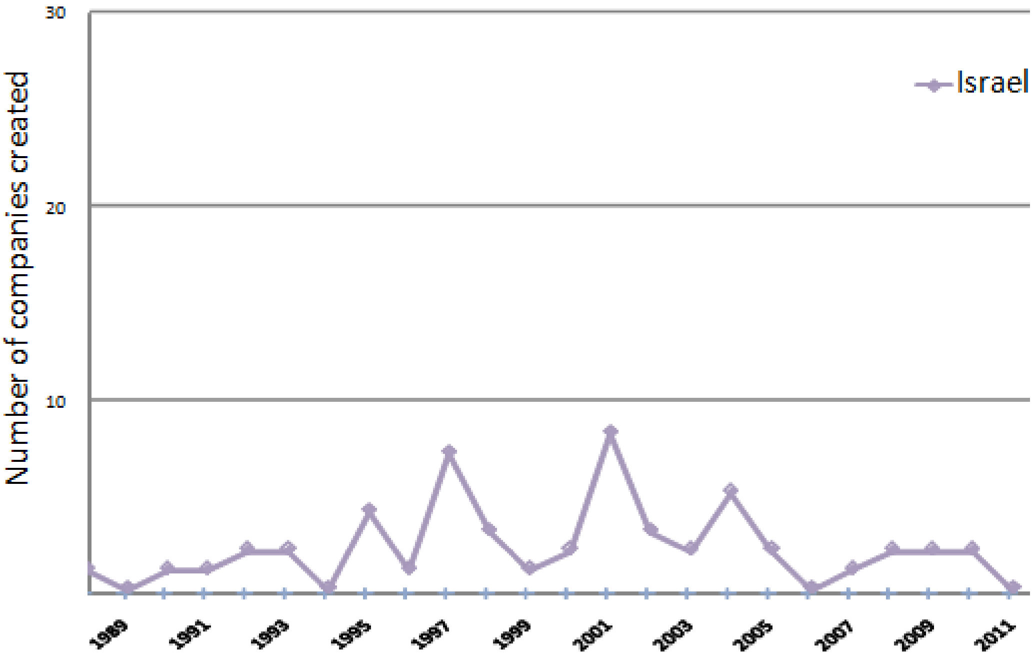

Figure 53. Creation of 52 nanotechnology companies in Israel from 1988 to 2011.

INNI has identified 110 companies and universities working in the field of nanotechnology in Israel; Matimop identifies sixty such companies only . These Figures show the strength of the industry, especially since the majority of these SMEs has entered into partnerships with companies in the USA and South East Asia, albeit relatively few in Europe. A number of Israeli SMEs or start-ups have been bought by foreign entities whose Directors or CEOs are Israelis.

Our study has identified 72 companies. Israel ranks 7th, in terms of number of companies, among the 13 countries in this study. The country started creating nanotechnology companies early, but suffered a sharp drop in 1998 and 1999 (Figure 53). The peak observed in 2001 may be linked to the creation of INNI. A moderately sized peak between 2003 and 2004 may be related to government efforts made between 2003 and 2007. The priority designated by the government in 2007 has probably caused a small recovery.

Figures 54 and 55 indicate that all business sectors are represented.

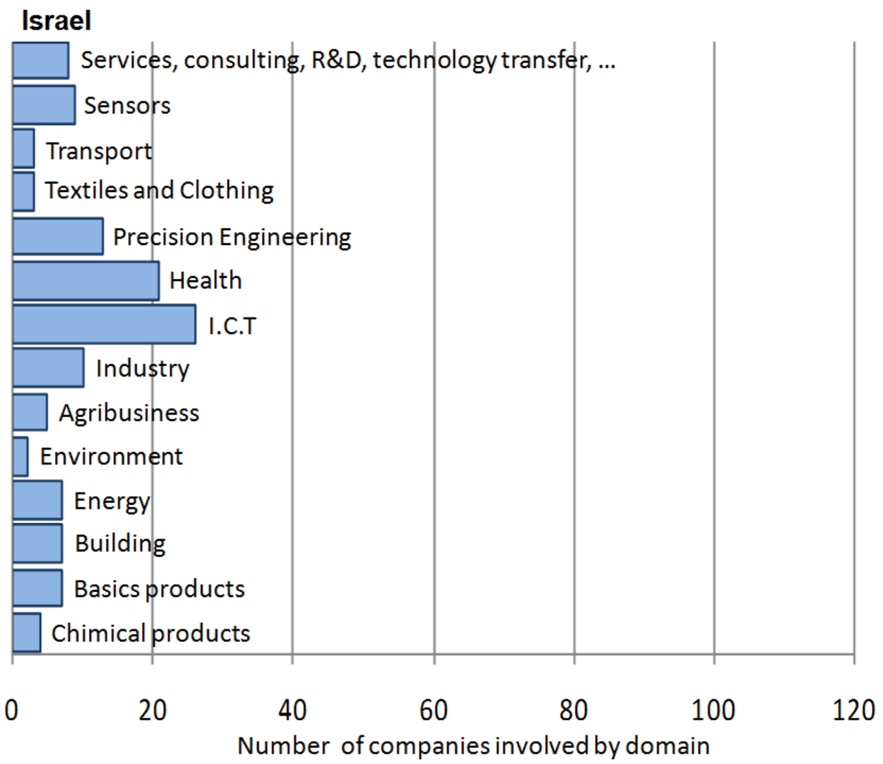

Figure 54. Distribution of the 72 Israeli companies identified.

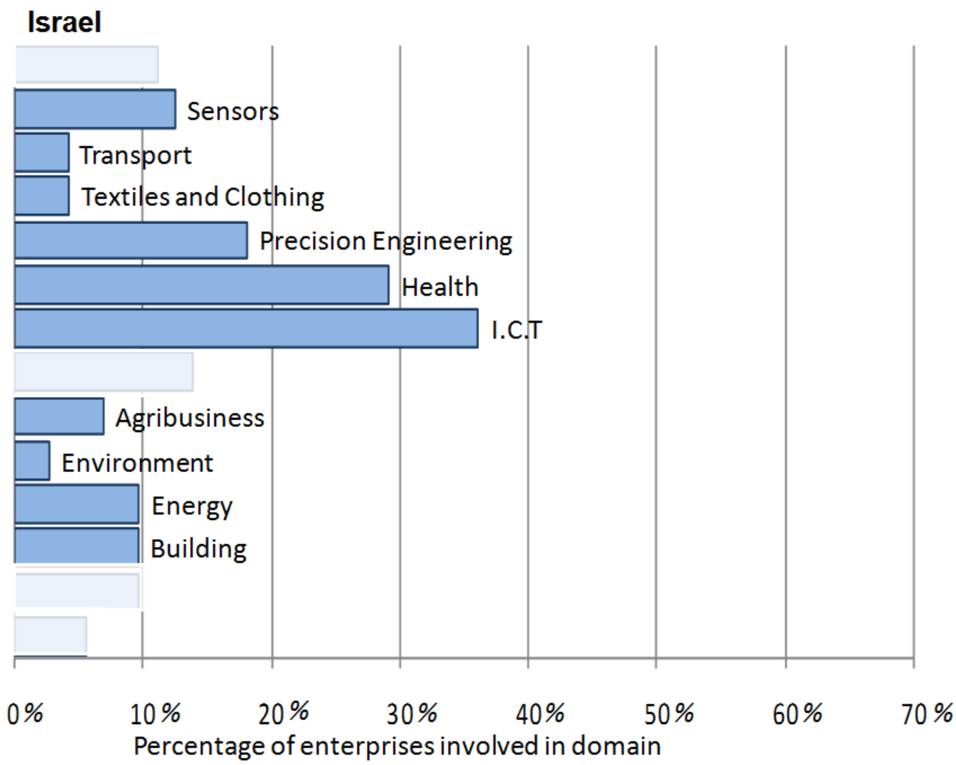

Figure 55. Distribution of the 72 Israeli Companies in the 10 areas of interest (%).

Based on these criteria[68], Israel has strong capabilities in information and communication technologies and medical applications and average capabilities in precision mechanics, sensors, energy, construction and food processing.

Conclusion

In terms of nanotechnology, Israel appears as a benchmark country, together with Germany and the United States.

In Israel, nanotechnologies have been defined as strategic by the state; they receive financial support from American institutions. They are at least about 85% dual. This analysis shows that there are many Israeli companies in the information and communication technologies and the medical. fields

[68] See Section 7.1.3 of this report.

IV.11 Japan

IV.11.a Master data

Population (2011)	127.7 millions
Area	378,000 sq. km
Average population density	340 residents/sq. km
GDP (2011)	$ 5,855 billions
GDP/inhabitant	$ 42,820
HDI (2009)	0.901

IV.11.b Japan's efforts[69]

In the late 90s, Japan, became aware of the exceptional challenge from nanotechnologies when associated with other technology areas and with industry, since they provide for "upgrading" existing performances. This is why Japanese state agencies have greatly encouraged emergence of an industrial base capable of performing R & D in these areas.

In Japan, most of nanotechnology financing is done through the Ministries of *Education, Sports, Science and Technology* (MEXT), and of *Economy, Trade and Industry* (METI). These departments support basic and applied research through the *Japan Science and Technology Agency* (JST). Most industry-focused programs, including funding of demonstration activities, are through the *New Energy and Industrial Technology Development Organization* (NEDO). In 2009, nanotechnology accounted for 5.2% of the third Science and Technology Basic Plan. However, for the fourth plan due to begin in 2011, nanotechnology will no longer be considered a priority, which will switch to innovation in "life" and ecology fields.

This chapter does not cover efforts made in the early stages; we chose to present the forecast below, established by *Nomura Research Institute* (NRI), which is both very explicit on the development of nanotechnology in the country and representative of R&D (market size).

[69] Eleanor O'Rourke and Mark Morrison, Developments and policy concerns, *Review of international nanotechnology*, Institute of Nanotechnology, United Kingdom OCDE - DSTI/STP/NANO(2012)12, 16 March 2012, Japan.
The Energy and Resources Institute (TERI), October 2009, Japan, page 33.
Review of international nanotechnology: Developments and policy concerns, TERI project: Capability, Governance, and Nanotechnology.
Les USA et le Japon devancent l'Europe pour les brevets en nanotechnologie, *Bulletin Electronique Etats-Unis* N°35 - French Embassy in the United States.

Forecasting the size of the Japanese nanotechnology products market 2010/2015

Nomura Research Institute, Ltd - July 20, 2006

Nomura Research Institute Ltd has forecast the size of the market for nanotechnology-related products on a domestic production basis (Figure 56). This projection covers eight basic elements of this market. These items are automotive consumer products, bicycles components, products for industrial robots, dental, orthopedic and medical products, energy- or environment-related electronic products, materials, and measuring devices. Projections showed that the market was Yen 942.1 billion as a whole in 2004, and is expected to grow to Yen 5649.8 billion in 2010 and Yen 23,061.2 billion by 2015.

NRI believes that said market growth will result from: (1) existing market growth by means of nanotechnology, (2) replacement of existing products with products using nanotechnology and (3) emergence of a new market through practical application of nanotechnologies. Therefore, methods that can be commonly used for these topics were adopted for market size calculation. More specifically, NRI has assumed nanotechnology products growth rates of replacing existing products with products using nanotechnology and has estimated the cost ratio of the nanotechnology part in each product. The market size was then calculated by multiplying the actual production amount (value of shipments) for existing products by these rates.

NRI believes that, for new companies to be created, it is essential that knowledge be shared by all those engaged in related fields, such as research, product development, manufacturing and marketing. One way to achieve this goal of shared knowledge is "technology visualization."

The table below contains estimates of various types of consumer products, allowing the reader to identify the strengths of Japanese nanotechnology industry and assess possible partnership opportunities. These results compare to the type of Japanese industries in 2010, which in turn corresponds to the existing (number of enterprises by theme) in these areas. This distribution is presented in detail further down. Peaks are consistent with those forecast for 2010 by NRI, which give credibility to forecasts for 2015.

Forecast of size of nanotechnology product market(on a domestic production basis) (Unit: Billion yen)

Forecast items		2004 (estimate)	2010	2015
Consumer products	Health-related goods	9.0	31.3	62.4
	Cosmetics	0.8	29.4	56.7
	Nano-textile fiber/hosiery	4.8	112.0	191.7
	Subtotal	17.7	194.3	346.0
Automotive/bicycle products		10.3	240.4	586.7
Industrial robot products		6.8	234.9	2,167.6
Dental, orthopedic and medical products	Dental and orthopedic products	1.4	18.9	53.8
	Medical products	7.6	470.7	3,385.1
	Subtotal	8.9	489.6	3,438.9
Electronics products	Integrated circuit devices	29.4	131.3	604.3
	Magnetic and optical memory	7.4	156.0	486.4
	Optical components	37.6	549.7	2,904.0
	Electronic components	53.9	638.1	3,394.8
	Subtotal	128.3	1,475.0	7,389.6
Energy/environment-related products	Components for fuel cells	4.7	159.8	1,599.8
	Components for lithium secondary batteries	8.3	55.4	113.1
	Electric double-layer capacitors	1.6	7.1	22.6
	Solar cells	2.2	196.1	813.1
	Nanocatalysts	259.1	814.7	2,117.1
	Subtotal	275.8	1,233.1	4,665.8
Materials	Inorganic materials	42.4	354.1	1,333.2
	High polymer materials	48.7	318.7	648.9
	Subtotal	91.2	672.8	1,982.1
Measuring devices and equipment	Nano measuring devices	84.9	194.4	391.7
	Nano processing and film forming devices	318.2	915.3	2,092.9
	Subtotal	403.1	1,109.7	2,484.6
	Total	942.1	5,649.8	23,061.2

Figure 56. Forecast of nanotechnology products market size (on a domestic basis). Unit: billion yen.

1€ ~ 100¥

IV.11.c Evolution of number of patents

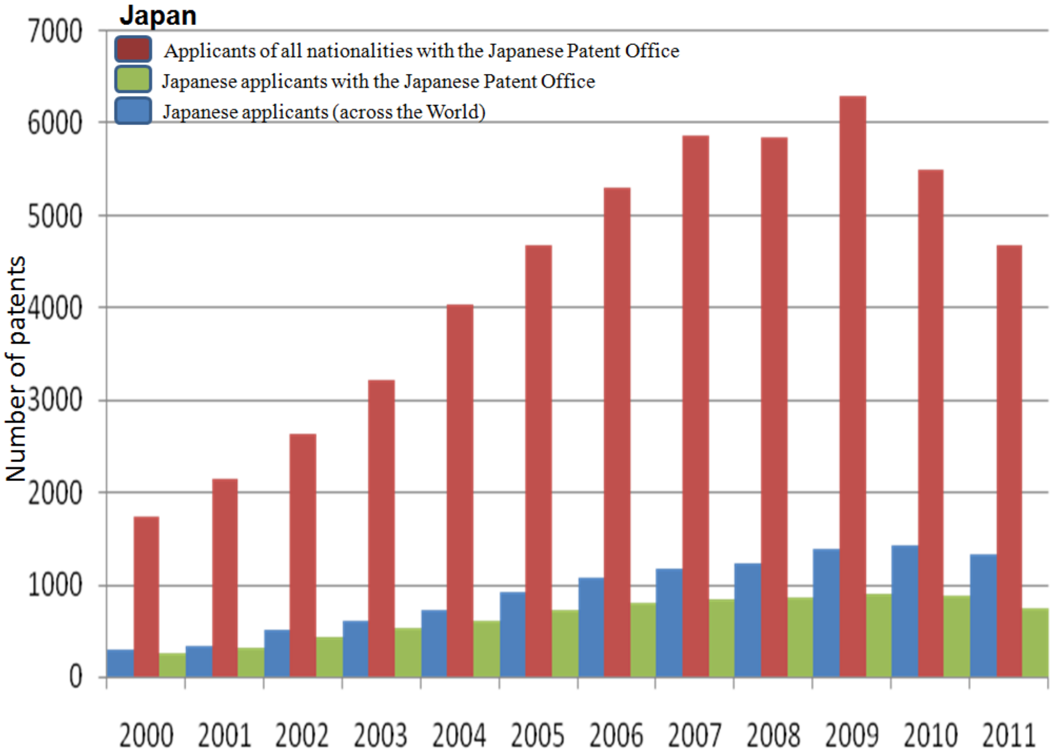

Figure 57. Patents published in Japan between 2000 and 2011.

In terms of patent filing, Japan's performance is impressive. There was a steady increase from 2000 to 2009, followed by a significant decline (Figure 57).

IV.11.d Types of companies

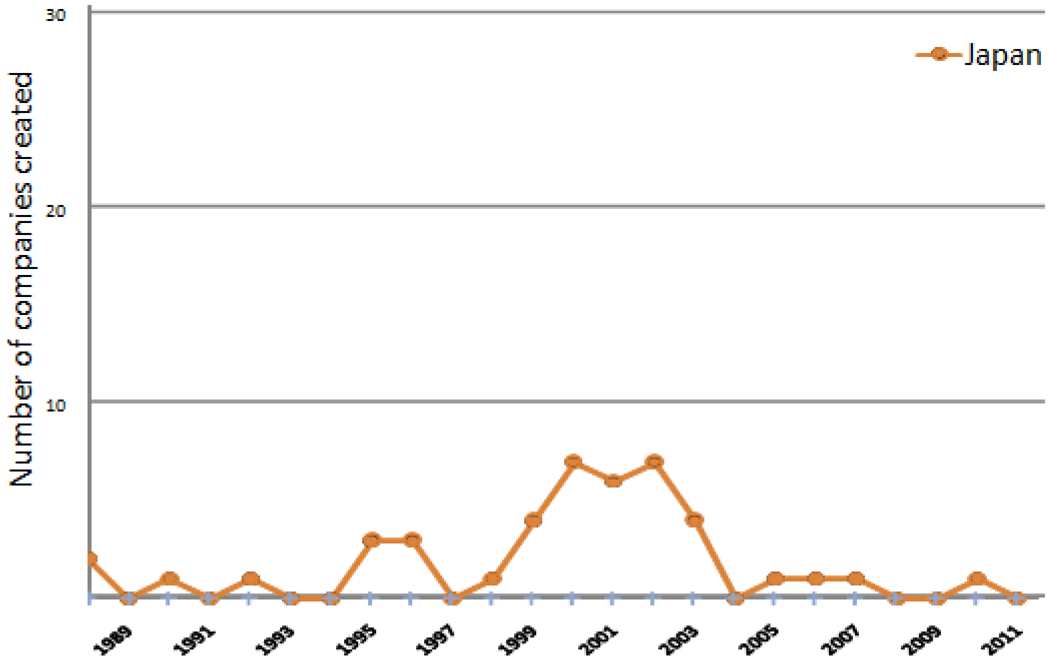

Figure 58. Creation of 43 nanotechnology companies in Japan from 1988 to 2011.

The total number of companies listed in this study is 112, including 43 created between 1988 and 2011 (rank: 4th out of the 13 countries in this study). Nanotechnology activities are thus performed largely by existing firms, and type field has not generated many business start-ups. The chart shows initial start of activity in 1995. There is a double peak, in 2000 and 2002, maybe related to the double peak of patents visible 7 years later. Then, after 2004, business creation virtually stopped.

Figure 58 shows the activity areas of these companies.

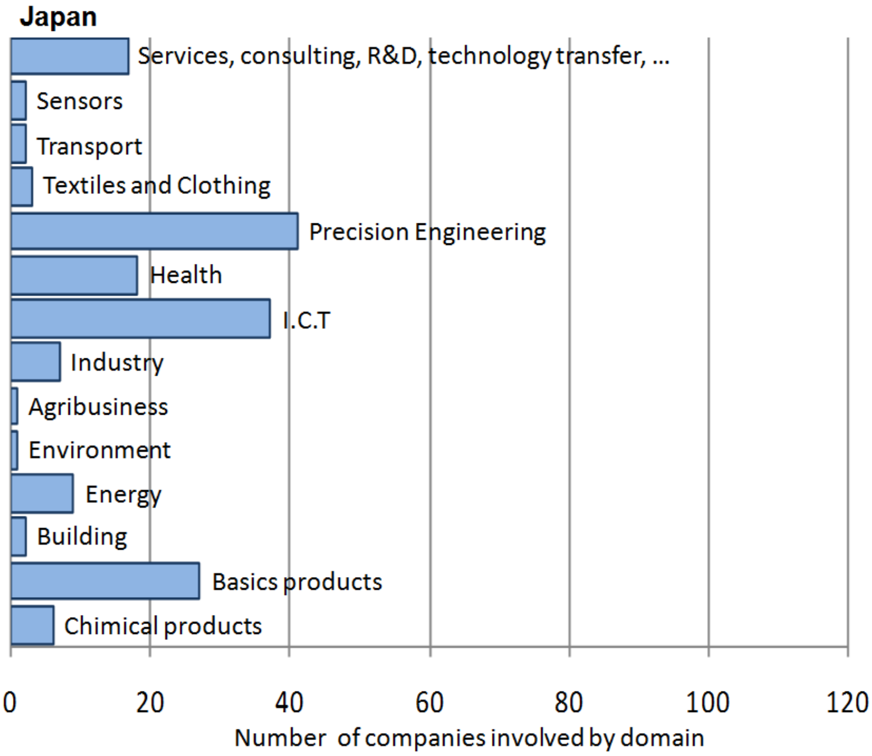

Figure 59. Distribution of 112 identified Japanese companies (%).

The best represented areas are precision engineering and information and communication technologies, followed by commodities.

Figure 60 shows the distribution (in percent) of the 112 companies in the 10 areas identified as potentially related to military and / or security applications..

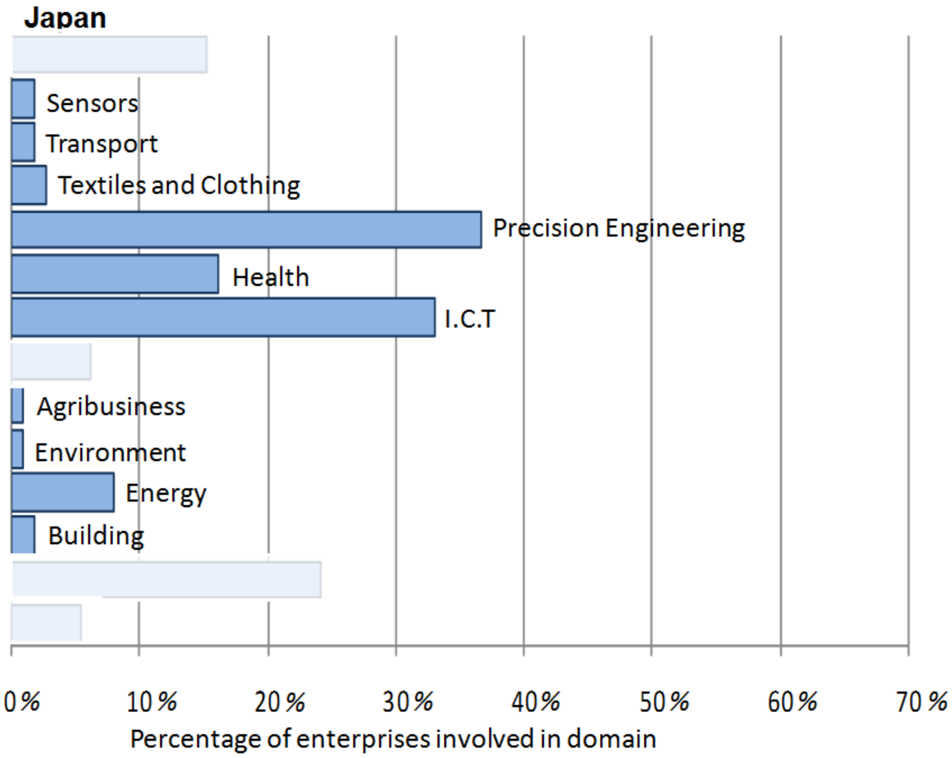

Figure 60. Distribution (%) of 112 Japanese companies in the 10 selected areas.

Conclusion

Japan has a strong industrial base dedicated to nanotechnology.

Forecasts, until 2015, made by *Nomura Research Institute*, about the size of the Japanese market for nanotechnology products, are essentially consistent with the analysis of the studied company types, which highlights those areas currently showing strong industrial applications.

IV.12 United Kingdom

IV.12.a Master data

Population (2011)	62 millions
Area	0,2 million sq. km
Average population density	260 residents/sq. km
GDP (2011)	USD 2,480 billion
GDP/inhabitant (2010)	USD 35,000
HDI (2010)	0.884

IV.12.b UK's efforts

In the UK, public nanotechnology research is coordinated by the *Nanotechnology Research Coordination Group* (NRCG), chaired by Defra [70]; it includes ministries and government agencies, research councils and related administrations.

(see Appendix 5: United Kingdom, Appendix 1)

Within the UK Research Councils, *RCUK Nanotechnology Group*, led by EPSRC[71], coordinating a program between all research councils, some of which may have their own nanotechnology programs:

- *Nanoscience through engineering to application* (EPSRC);
- *Environmental Nanoscience Initiative*, involving the Natural Environment Research Council, Defra and the Environment Agency.

Within this structure, responsibility for basic research is assigned to research councils.

There are about 20 EPSRC-funded universities working in the field of nanotechnology[72].

Currently, the UK does not have a government program underway to support nanotechnology. There are a number of existing projects, but the current plans for science funding by the Government for 2011-2015, as defined in the various research council documents, reveals no future role for nanotechnology. The previous inter-councils program "engineering through the application of nanoscience" has been abandoned.

All inter-Councils programs are inscribed in social issues such as population aging, environmental change, global security, energy, food security and the digital economy. The

[70] Department for Environment, Food and Rural Affairs.

[71] Engineering and Physical Sciences Research Council

[72] Oxford (bio-nanotechnologies), Cambridge (nanofabrication), Durham, Sheffield, Surrey, Birmingham, Nottingham, Starthclyde, Southampton, Glasgow, Manchester, Bristol, Edinburgh, Cardiff, Leeds, Queen's University of Belfast, Bath, Exeter, University College of London et Imperial College of London.

Delivery Plan for Engineering and Physical Sciences of the Research Council, which is the leading council for nanotechnologies, doesn't even mention the word73.

Defining precisely UK government spending in terms of R&D for nanotechnology is difficult, mainly for lack of distinction between micro- and nanotechnology (MNT). That being said, public spending on nanotechnology over the last 12 years can be estimated at over £ 640 million.

Over the past five years, the government has invested significantly in the MNT community, including for example £ 90 million aimed at developing a new network of equipment and services.

EPSRC has invested £ 253 million since 2003, distributed on a portfolio of over 400 projects, the most important of them being:

- *Grand Challenge for Healthcare* (19 projects totaling £ 16.6 million), and
- *Grand Challenge for Energy* (2 projects totaling £ 6.78 million).

The Ministry of Defense, EPSC, the *Biotechnology and Biological Sciences Research Council* (BBSRC) and the *Medical Research Council* (MRC) have contributed £ 19.4 million (£ 3.4 million, £ 10 million, £ 3 million and £ 3 million, respectively) for the implementation of multidisciplinary research centers in nanotechnology (*Interdisciplinary Research Centres* - IRC).

Regarding legislation, the *Department of Trade & Industry* (DTI) published a report in December 2006. This document identifies a number of regulatory gaps[74]. However, it concludes that they do not exist because of omission but rather due to lack of knowledge about the effects of nanoparticles on human health and the environment.

On June 1, 2007, the European REACH regulation[75] entered into force. Except for certain types of nanomaterials (such as fullerene), which are considered as new and addressed specifically by this regulation, particle size does not influence the way materials are classified. This means that most nanomaterials are classified and treated as if they were massive materials.

The British government has supported a number of initiatives to promote dialogue on nanotechnologies. For example:

- *Nanodialogues* which, under the *Sciencewise* program, covers various applications of nanotechnology. This initiative was supported to the tune of £ 120,000 by the DTI, equivalent funding being provided by other sources.*Small Talk*, with a budget of £ 50,000 (around € 73,000), which implies discussion of nanotechnology with the public and scientists.

[73] It's the same for the last strategy paper from the Technology Strategy Board, body responsible for supporting R & D for products close of the market, for which nanotechnologies are "now incorporated in all subjects where there are such opportunities."

[74] Defra identifies a number of regulatory gaps, particularly with regard to threshold values and exemptions laid down in existing legislation, current scientific knowledge and understanding of risk, lack of information and vagueness of certain definitions, and finally, reliable and validated methods to control exposure and possible effects on human health and the environment.

[75] Regulation on the Registration, Evaluation, Authorization and Restriction of Chemicals.

- *Nano Jury UK* initiative which allowed fifteen people selected at random to discuss nanotechnology-related issues.

These initiatives have sent messages to the political class: The public has a rather positive attitude to nanotechnology but expects the government to finance research on potential risks associated with them. However, these initiatives do not seem to have had a major influence.

IV.12.c Priority sectors.

Announced in 2009 in response to the report from the *Royal Commission on Environmental Pollution*, British strategy on nanotechnology was published March 18, 2010, after consultation with a panel of experts from academia, industry and NGOs.

This strategy is built around four themes, for which more than 40 operations to develop, to regulate and to promote the safe use of nanotechnology have been exposed. We will retain:

- Companies (Innovation and Industry)
- Environment, health and safety
- Regulations
- The interaction between British government with researchers, industry and consumers

IV.12.d Evolution of number of patents

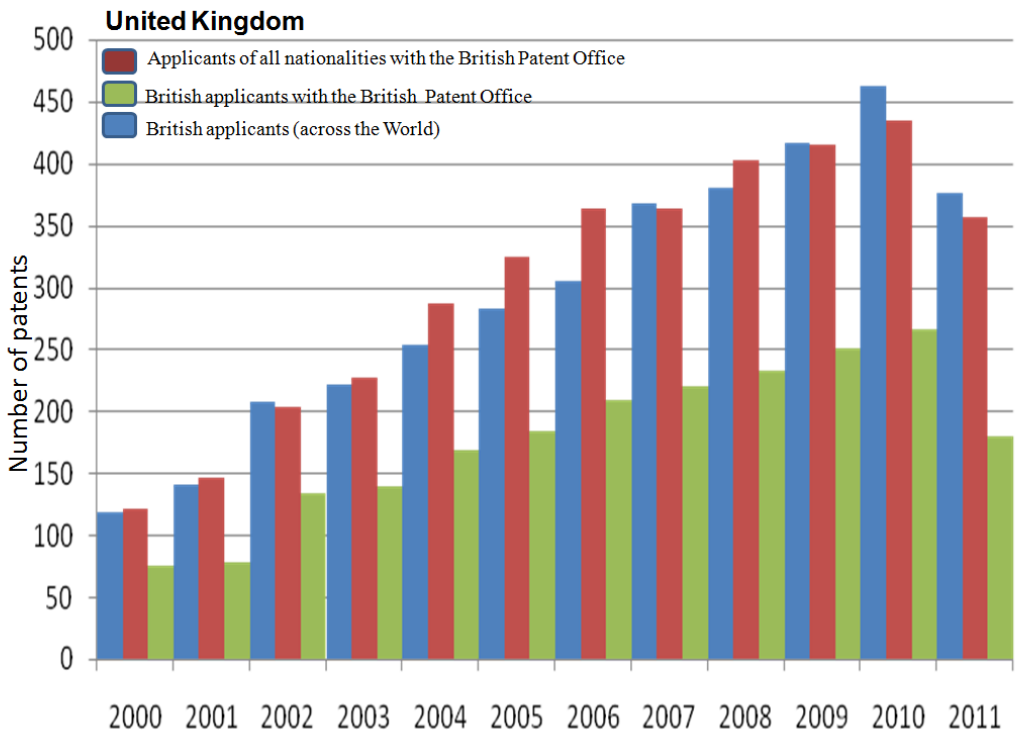

Figure 61. Patents issued in United Kingdom between 2000 and 2011.

Compared to other countries analyzed in this study, the number of patents is low and places the UK at the 8th position. However, we note that, with the exception of 2011, patent filings have been steadily increasing (Figure 61). The gap is small between British applicants and applicants from all nationalities.

IV.12.e United Kingdom on the international scene

Internationally, the United Kingdom is actively involved in international R&D cooperation, as well as in the industry.

- Collaboration in R&D: through *Nanosafe 2* et *Nanosh* which are European research projects. The *Nanoparticle Occupational Safety and Health* (NOSH) consortium of industrial organizations, academic, governmental and international nongovernmental which, since 2006, has been trying to obtain risk data for health and occupational safety associated with nanoparticles, must also be mentioned.Collaboration in industry: Through cooperation and investments abroad.

Both types of collaborations are described in Figure 62.

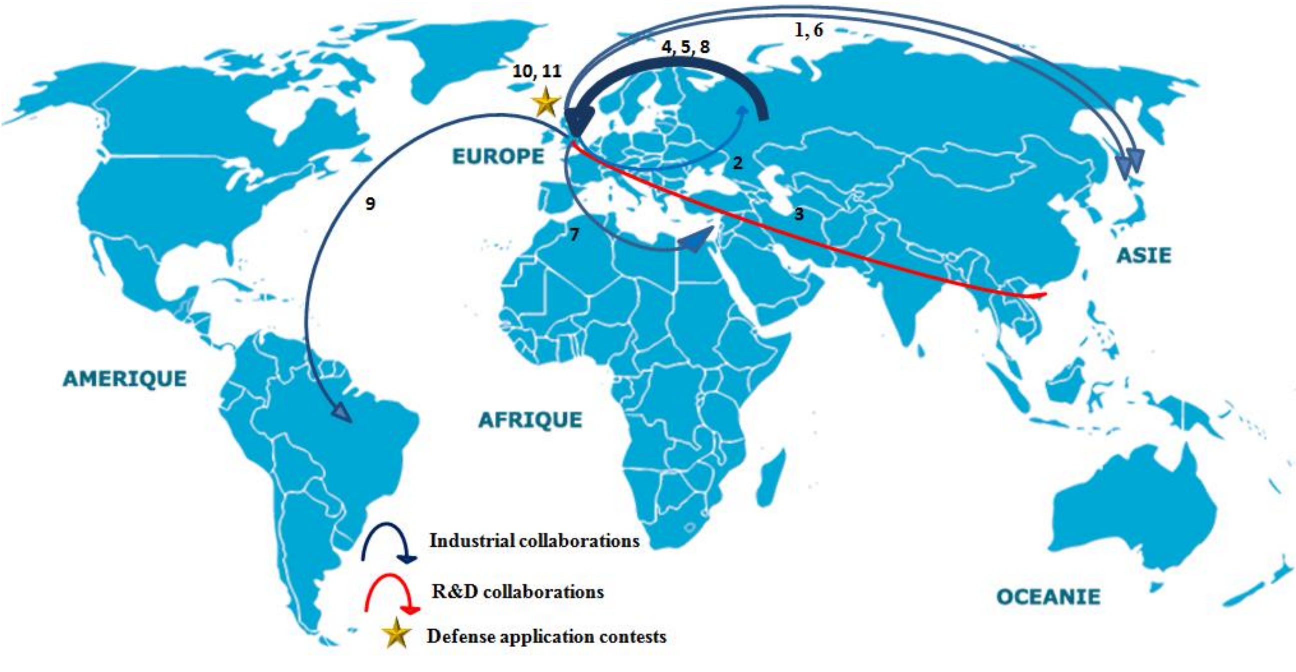

Figure 62. British investment and cooperation abroad.

1. *Nanoco*, a nanotechnology company in Manchester (60 employees), has warned that it will relocate its plant to Japan or Singapore if it does not receive financial assistance from the government. Such plant would cost £ 10 million and employ 30 additional people[76].

2. To strengthen relations with Russian companies, and with financial support of the Board *Technology Strategy*, UK SMEs have participated in the *NanoMicroClub* (INMC)

[76] Peter Marsh, Nano-tech company pushes for public cash, *Financial Times*, 3 July 2011.

international event in Russia. Some of these SMEs were already in a funding application process with RUSNANO[77].

3. The existing relationship between the UK and South Korea have been strengthened by the signing of a Memorandum of Understanding (MoU) between STFC and the *Korea Research Council on basic science and technology* (KRCF)[78].

4. RUSNANO is investing $ 700 million in *Plastic Logic* (flexible plastic electronic display, UK). This will fund a plastic electronics factory in Zelenograd[79].

5. RUSNANO plans $ 900 million for a pharmaceutical project with UK companies [80].

6. British SMEs visited the *Nanotech 2011* show in Tokyo [81].

7. Ten 10 British industrialists took part in the Eilat-Eliot Israeli conference, funded by Science and Innovation Network (NAS) to foster productive partnerships in the field of renewable energy[82].

8. RUSNANO and Celtic Pharma Holdings (investment funds, Great Britain) are creating the Russian international biopharmaceutical company *Pro Bono Bio*. The total amount of money that might be invested by RUSNANO is $ 300 million[83].

9. Collaboration between Brazil and the United Kingdom as part of a network on innovation in the biosciences. To enable a transfer of knowledge and to promote the interaction of members of *Biosciences KTN* with part of the investment community from Brazil[84].

10. SBRI & MOD armor and protection contest[85].

11. The Centre for Defense Enterprise (CDE) of the Ministry of Defense has launched a contest to find new low cost technologies for future complex weapons [86].

British companies occasionally encounter difficulties to finance their development. In this context, they turn to foreign countries such as Russia. Production lines are then relocated.

[77] Fionna Brewer, Announces Success of UK Nanotechnology Mission to Russia, NanoKTN, 24 June 2011.

[78] Lucy Stone, *UK and Korea stand together for the future of science*, STFC Rutherford Appleton Laboratory, 27 October 2010.

[79] *Rusnano Finalizes Investment in Plastic Logic: $700 Million Total Investment Project Will Include Building World's Largest Commercial Plastic Electronics Factory in Zelenograd,* Rusnano, 18 January 2011.

[80] RusNano plans $900 for a pharmaceutical project with British business, *RIA Novosti*, 25 November 2011.

[81] Del Stark,*UK Nanotechnology SMEs take to Japan for business*, Institute of Nanotechnology,22 February 2011.

[82] Arnold Black, ES KTN secures funding for Renewable Energy Mission to Israel, 7 September 2010

[83] Rusnano and Celtic Pharma Holdings (Great Britain) Establish International Pharmaceutical Company Pro Bono Bio, Rusnano, 12 september 2011.

[84] The network will invest in venture capital in Brazil, with direct access to UK companies that are particularly suited to the markets of the Brazilian biotechnology and to the member companies that might have an interest in seeking financing and/or collaborations in Brazil.

[85] *Novel Technologies for Complex Weapons*, Ministry of Defence; DSTL, 27 January 2011.

[86] Toby Gill, *Novel technologies for complex weapons*, 6 January 2011.

IV.12.f Types of companies

The number of companies created annually in the UK, employing nanotechnology, shows a fairly strong growth over the last twenty years, as shown in Figure 63:

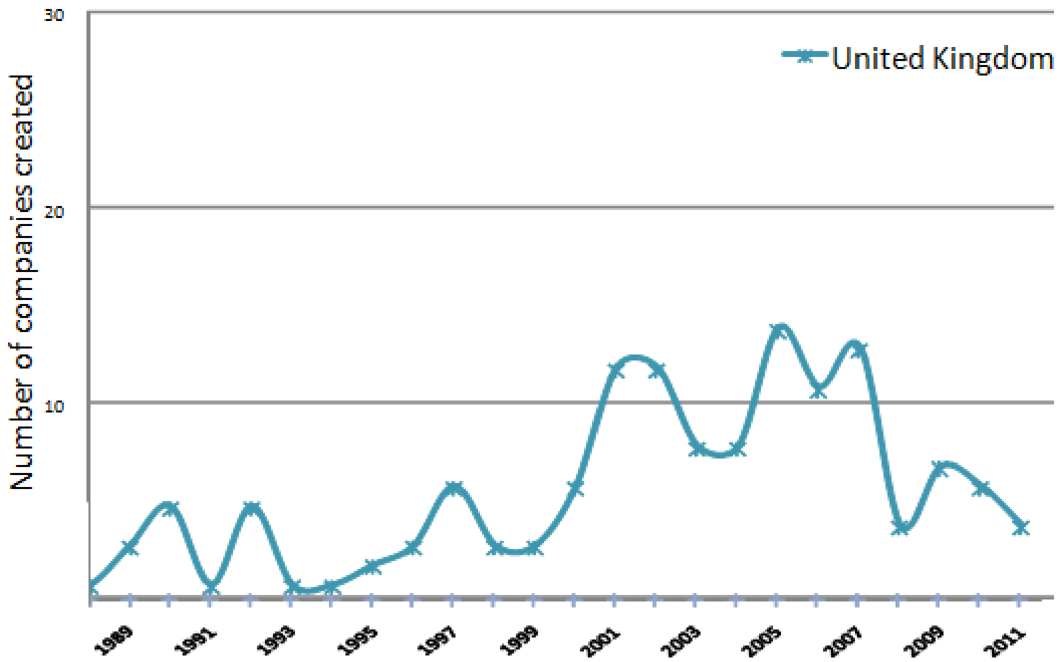

Figure 63. Nanotechnology company creations in the UK from 1988 to 2011.

The total number of companies in this study is 158, 115 of which were created between 1988 and 2011.

The industrial sector comprises a mixture of young innovative companies, SMEs, large companies and multinationals. A progressive start of activities between 1996 and 2001 is shown, but during 2001-2007 the number of created company is the most important.

Compared to other countries studied, the United Kingdom started creating companies belatedly. A drop was noted in 2003 and again in 2005, perhaps related to MNT program. Since 2008, a sharp drop of activity has been observed, certainly due to the global economic environment and withdrawal of the state. This has probably affected the number of patents registered in 2011.

Figure 64 indicates that all business activity areas are represented.

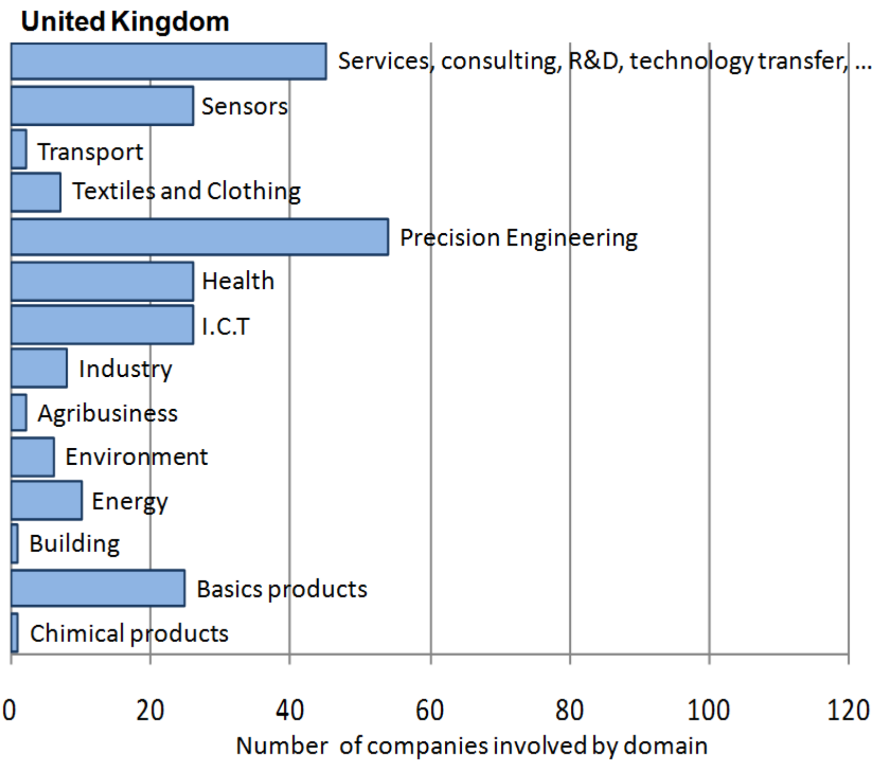

Figure 64. Distribution of the UK companies identified.

The strong presence in precision mechanics, specifically metrology, is related to the British interest to the potential toxicity of nanomaterials[87]. The UK is more focused on nanomaterial integration than about their manufacture (commodities). Indeed, production of nanomaterials isn't necessarily where the biggest financial margin is. Value can be generated by theoretical development, design, manufacture of new techniques, sale of intellectual properties and licensing to other countries. The UK has a good industrial capacity for thin layer deposition (precision mechanics).

Figure 65 shows the distribution (in percent) of the 158 companies in the 10 areas identified as potentially related to military and / or security applications.

[87] Metrology is crucial for the detection, measurement and classification of nanomaterials. It can also measure workplace exposure and create standards used in regulation or toxicological studies.

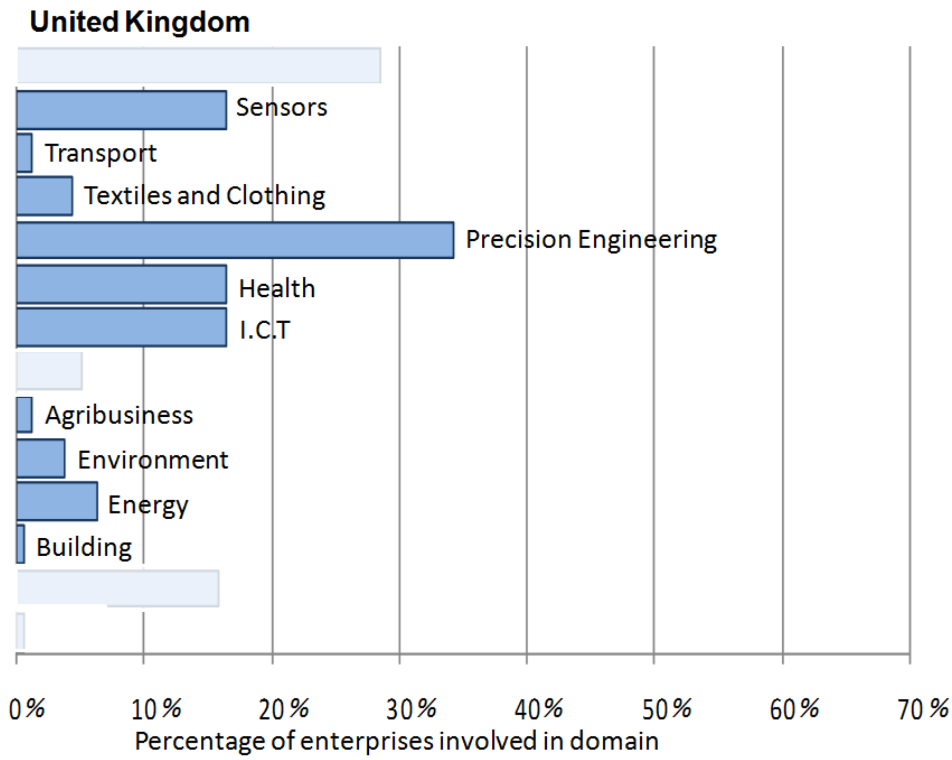

Figure 65. Distribution of UK companies in the 10 areas of interest (%).

Based on the criteria we have chosen[88], the UK has strong capabilities in precision mechanics, and average capabilities in sensors, information and communications technology[89] and medicine are at an intermediate level.

Conclusion

In recent decades, the UK has gained a lead in the areas of science and engineering, and has found that the main commercial applications of these technologies are developed abroad. What began as a vision and a clear strategy seems to get bogged down in bureaucracy and misunderstanding. Funding for R&D was not enough and has not been fully exploited to ensure a strategic impact.

The majority of the UK R&D in nanotechnology is concentrated in academia with strong expertise and academic foundation. Although the scientific base is strong and many organizations are currently involved in commercialization, the country has to face competition from other scientific nations. In 2004, following the publication of the report of the two scholarly academies, and the response provided by the government, the United Kingdom was at the forefront of engagement in nanotechnology. But many stakeholders in the field, whether

[88] See Section 1.1.3 of the report.

[89] It is likely that 2015 market penetration will be by data storage products and display thanks to RAM technology using magnetic nanoparticles (ultra-thin and light random access memory), to flexible displays with low power consumption and carbon nanotube field emission screens.

from industry, academia, learned societies and NGOs share the view that the country has lost the leading position. However, it could regain it if actions were resolutely implemented.

The UK is also plagued by many concerns:

- What might be the impact of new nanomaterials on human health?
- What types of applications might arise from the convergence of nanotechnology, on one hand, and biotechnology, computer science or artificial intelligence, on the other?
- Are the current regulatory frameworks relevant?

However the *Council for Science and Technology* believes that the government has advanced significantly on a number of commitments (international cooperation, standardization, application of the precautionary principle, collaboration with industry, reporting system on a voluntary basis, etc.).

See Appendix 5, Appendix 2

IV.13 Russia

IV.13.a Master data

Population (2012)	143 millions
Area	17 million sq. km
Average population density	8,3 residents/sq. km
GDP (2011)	1,884 billion $
GDP/inhabitant	15,9000$
HDI (2009)	0.817

IV.13.b Russia's efforts

After a difficult decade of declining funding and brain drain, conditions for development of Russian R&D have become favorable again. In this context, development of nanotechnology has become a priority in Russia; it is coordinated at the highest political level and enjoys significant resources.

While some countries such as the US, Germany and Japan, have made nanotechnology a priority of their research and innovation policy in years 1990, there was also intense activity in the leading Russian scientific centers for the development of nanotechnologies during this period. Russia has therefore not taken any significant delay in relation to Western advances. Indeed, based on very good basic knowledge of solid physics, crystallography, quantum mechanics, theoretical physics, laser physics, biophysics and genetics, Russian research has been able to take the turn to these new technologies. However, until 2004-2005, organization of nanotechnology R&D remained relatively uncoordinated, due to a lack of consultation of the main stakeholders, and was essentially based on individual initiatives.

Strong government support

"We are almost ready for a new revolution in science and technology: revolution in nanotechnology."

Andreï Forenko, Minister of Science and Education, February 2008.

Presidential Support

Interest in nanotechnology appeared publicly, in 2006, through speeches of President Vladimir Putin, who called for creation of a program dedicated to their development in Russia, while stressing that the country could quickly become a world leader in this field with strong potential[90].

Later, Vladimir Putin, at this time Prime Minister, continued to encourage nanotechnology by strongly supporting the Rosnanotech project: according to him, nanotechnology is a "key vector of industry and science development."

[90] Christian Harbulot course, *Les nanotechnologies: nouvel instrument dans la stratégie de puissance de la Fédération de Russie*, Paris, 11 November 2008.

Established in 2007, Rosnanotech (RUSNANO) was awarded a € 3.2 billion budget, i.e. an unprecedented level of funding for Russian science since the fall of the USSR. However, public resources are not sufficient and should be used to encourage private investment. One of the main priorities of the new innovation-based Russian economy will be to create the nano-industry. The role of Rosnanotech is to make inventions of Russian scientists commercially viable and encourage private investment. Since 2011, Rosnanotech was reorganized and the government holds 100% of shares.

Furthermore, former Russian president Dmitry Medvedev posted, in 2010; ambitions to build in Moscow a city of innovative companies, *Skolkovo*, worthy of Silicon Valley. The city should have laboratories, companies and training centers in all high tech areas, including nanotechnology.

Support of State Duma

In 2007, the State Duma Speaker, Boris Gryzlov, said that Russia had everything to become a world leader in the field of nanotechnology. According to him, "Russia can boast a great combination of intelligence and possibilities, and it should not be a country that performs simple progress in the sphere of nanotechnology: it must make leaps in that direction, and we could become world leader on this axis." "The scale of Russian achievements in the field of nanotechnology will define the place of Russia in the global economy, the level of our competitiveness and our national security, the defense component included," he said[91].

All these actions make nanotechnology a priority policy, and the economic sector where Russia wants to position itself as a world leader.

IV.13.c Priority sectors.

Five major Russian institutions[92] working solely on nanoscience, often from the physics of solids, can be identified. In others already specialized institutes (inorganic chemistry, catalysis), these are teams which have turned to nanoscience and obtained interesting results. There are also institutes playing an important role in the nanotechnology policy.

Although Russia is traditionally specialized in innovative materials, it has nevertheless developed the following nanotechnology application themes:

- **effects related to electrons:** electronics, optoelectronics, magnetic memories, Giga and TeraHertz wave radiators, sensors and detectors, imaging (especially medical), superconductivity;**instruments**: near-field microscopy (atomic force, tunneling, SNOM, etc.), nano-biotechnology (biochips);
- **materials**: materials reinforcement, super hard materials, special alloys, quasicrystals, ultrafiltration, functional coatings in thin layers, nanotubes and crystals of all kinds and shapes, antibacterial paints, etc.

In particular, the following themes are being developed:

91 Moscow, *Ria Novosti*, 5 July 2007.

92 Five major areas of expertise have been listed: **Moscow**, **Saint-Petersburg**, **Chernogolovka**, **Nizhny-Novgorod**, et **Novossibirsk** (avec **Tomsk**). Excellent facilities are also identified in **Obninsk**, **Ekaterinbourg**, **Zelenograd** et **Troitsk**.

- **crystal growth;**
- **nanomaterials**: nanopowders of any kind (metals, ceramics), nanofibers, nanotubes and nanofilms;**superconducting nanostructures;**
- **spintronic**: nanomagnetism, memories.

IV.13.d Russia on the international scene

Collaboration in the R&D area

"Nano" Russian-European working group

This group was created to define themes of common interest, to encourage participation of Russian teams in the 7th European Framework Program (2003-2013)[93], but also to include Russia in the project assessment bodies.

Franco-Russian cooperation in the nanotechnology field

- Arcus Program on nanomaterials, between the Lorraine region and MISIS in Moscow.
- *Engelhardt Institute of Molecular Biology*/Laboratory of Virology - *CHU Toulouse Purpan*: Russian biochips technology in the field of hepatitis C.**Collaboration in the industrial sector:**

Today, technology cooperation involves large industrial companies. Several multinational companies have established an R&D activity in Russia, including *Schlumberger*, *Servier*, *Sun Microsystems*, *Motorola*, *EADS-Airbus*, *Microsoft*, *Cisco*, *Siemens*, *Hewlett Packard*. According to a recent UNCTAD report, Russia might become, by 2009, the 6th most attractive global destination for foreign investments in R&D. Rosnanotech aims to overcome the difficulties between development and marketing through investments at an early stage. It should be noted, however, that Rosnanotech is not restricted to this activity: It invests into advanced nanotechnology foreign companies in order to then build a production line in Russia and thus acquire the technology and production capacity (see diagram below, points 3, 4 and 9).

[93] In Europe, FP7 plays an important role in organization of research in nanoscience throughout the continent. The European Union announced more than a doubling of the budgets for framework programs which would increase from about € 20 billion (between 2002 and 2006) to 53.2 billion (for 2007-2013). As such, nanotechnology appear in good position in FP7 "cooperation" category, which essentially aims to encourage creation of partnerships between different European research teams (and partner countries), and to develop multidisciplinary and transverse research.

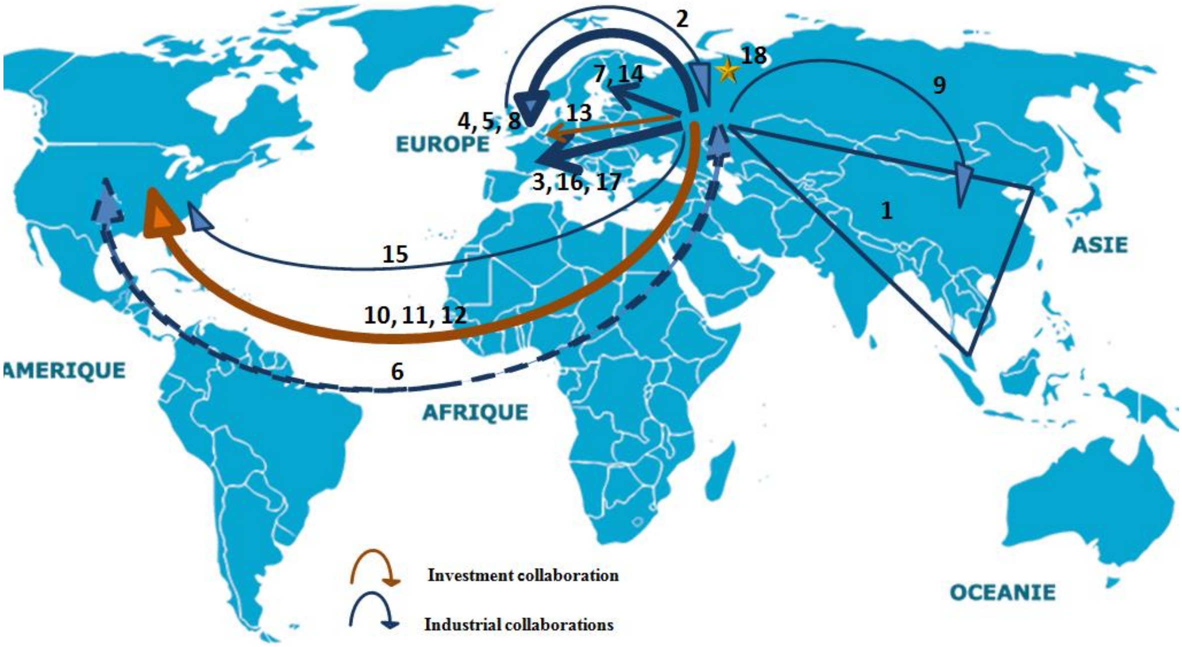

Figure 66. Russian international cooperation and investments.

International cooperation and investment ventures are as follows:

1. RUSNANO, the *Korea Institute for the Advancement of* Technology (KIT), *EDB* (*Singapore Economic Development Board*, international investor in Singapore) have created the Asian nanotechnology background, to develop research and development, and to get to market faster. 50% of the funds are invested in Russia[94].

2. The United Kingdom, represented by NanoMission, attended the NanoMicroClub (INMC) conference in November 2010. This is expected to lead to funding requests by British SMEs to RUSNANO, and other forms of collaboration[95].

3. *Crocus Technology* (90/65 nm lithography, MRAM, CEA Grenoble) and RUSNANO have created an MRAM manufacturing company in Russia named *Crocus Nano Electronics* (CNE), with a combined investment of $ 300 million. *Crocus* will invest $ 5 million, initially into Russian research organizations, to develop advanced manufacturing solutions[96].

4. RUSNANO is investing $ 700 million in *Plastic Logic* (flexible plastic electronic display, UK). This will fund a plastic electronics factory in Zelenograd[97].

5. RUSNANO is planning to invest $ 900 million for a pharmaceutical project with UK companies[98].

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[94] *Russia, Korea and Singapore Announce Launch of the Asia Nanotechnology Fund*, Rosnanotech, 16 juin 2011.

[95] Fiona Brewer, *NanoKTN Announces Success of UK Nanotechnology Mission to Russia*, Institute of nanotechnology, 2010.

[96] *Crocus Technology Strikes $300 Million Financing Deal with Rosnanotech to Build Advanced MRAM Manufacturing Facility in Russia*, Crocus technology, 17 mai 2011.

[97] *Rosnanotech Finalizes Investment in Plastic Logic: $700 Million Total Investment Project Will Include Building World's Largest Commercial Plastic Electronics Factory in Zelenograd*, Rosnanotech, 18 janvier 2011.

6. Rosnanotech; in collaboration with the American Business Association of Russian-speaking professionals AMBAR[99], brought US venture capital firms to Moscow in May 2010,.

RUSNANO opened an office in Silicon Valley to organize collaborations with American venture capital, high-tech companies, universities and technology transfer centers[100].

7. The Finland government-owned *Suomen Sijoitus Teollisuus Oy* (Finnish Industry Investment Ltd.) investment company and RUSNANO have signed a 3-year, € 50 million, nanotechnology investment agreement on a Finnish-Russian program[101].

8. RUSNANO and *Celtic Pharma Holdings* (investment funds, Great Britain) have created the *Pro Bono Bio* international Russian biopharmaceutical company. The total amount of money that can be invested by RUSNANO is $ 300 million[102].

9. A technology transfer project with a Chinese company Thunder Sky Group is among the projects funded by RUSNANO. A large-scale production of lithium-ion batteries for cars and buses was expected to be set up in Russia[103].

10. The I2BF-RNC (Rusnano Capital Tech: RNC) strategy to fund nanotechnology companies and facilitate the transfer of production sites in Russia was launched. I2BF is a New York venture capital firm which invests globally[104].

11. Joint investment between RUSNANO and *Domain MedInvest Associated* (US venture capital company) in California's *Coda Therapeutics* pharmaceutical company (treatment of wounds and inflammation), to install pharmaceutical and medical devices for advanced production of therapeutic products in Russia meeting GMP standards[105].

12. RUSNANO co-invested in *Business Development* Lilliputian VP to establish the R&D facility and manufacture the product in Moscow. The USB MPS is a lightweight, portable device that can recharge a variety of electronic products, providing true wireless mobility[106].

13. RUSNANO has invested in *Mapper Lithography*, developer of maskless lithography equipment. Beside expanding existing infrastructure in the Netherlands, part of the RUSNANO investment will be used to establish a production site in Russia for Mapper lens components[107].

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[98] Rosnanotech plans $900 million pharmaceutical project with British business, *RIA Novosti*, 25 novembre 2011.

[99] *US Venture Capitalists Discover Nanotechnology in Russia*, Nanowerk News, 24 avril 2010.

[100] *RUSNANO Opens Office in Silicon Valley*, Rusnano, 24 mars 2011.

[101] Finland and Russia to cooperate in nanotechnology investment, *Industry Investment*, 27 mai 2010.

[102] Rosnanotech and Celtic Pharma Holdings (Great Britain) Establish International Pharmaceutical Company Pro Bono Bio, Rosnanotech, 12 septembre 2011.

[103] *Russian Nanotechnology R&D: Thinking big about small scale science*, FOI Swedish Defence Research Agency, Fredrik Westerlund, juin 2011.

[104] *I2BF And RUSNANO Capital Announce Strategic Nanotechnology Resources Fund*, Rusnano Capital, 18 juillet 2012.

[105] *RUSNANO and Domain Associates Announce First Joint Investment*, Rusnanotech, 25 juillet 2012.

[106] *RUSNANO Leads Investment in Lilliputian Systems' $60 Million Equity Financing*, Rusnano, 14 septembre 2012.

[107] *RUSNANO Invests in MAPPER Lithography, Developer of Groundbreaking Maskless Lithography Equipment*, Rusnano, 23 août 2012.

14. RUSNANO has invested in *Beneq*, the Finnish pioneer and world leader in industrial production and laboratory equipment for nano-scale thin films and functional coatings[108].

15. RUSNANO has taken equity in *NeoPhotonics Corporation*, a leading designer and manufacturer of photonics integrated circuit. The company is expected to establish research and production facilities in Russia[109].

16. RUSNANO has taken equity in *Magnisense*, a French developer of in-vitro bioassays for diagnostic tests in health care, veterinary medicine, food safety and environmental protection. The new project will allow Russia to manufacture an advanced diagnostic system based on MIAtek's proprietary Magnisense[110] technology.

17. EADS, a global leader in aerospace and defense, grants technology licenses to RUSNANO by[111].

18. RUSNANO has created an international nanotechnology award in the Nano electronics, nanobiotechnology, nanomaterials and Nanodiagnostic fields[112].

The list above is just a sampling of the many actions carried out by Russia in many countries (India, Israel, etc.).

Since 2010, Rosnanotech no longer simply help develop Russian nanotechnology companies, but also takes equity in high-potential foreign companies to build production facilities in Russia with their support.

In 2012, Rosnanotech adopted a new strategy. It now co-invests with foreign funds in foreign companies to build production facilities in Russia.

While Rosnanotech targets nanotechnology companies, it invests in diverse and strategic areas: medical, semiconductor, solar cell, etc. This agency became close to the United States in 2012.

Russia has been acquiring strategic technology while de-industrializing other countries.

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[108] *RUSNANO Invests in Beneq*, Rusnano, 12 avril 2012.
[109] *NeoPhotonics Receives Strategic Investment from RUSNANO*, NeoPhotonics, 30 août 2012.
[110] *RUSNANO and France's Magnisense to Produce Diagnostic Systems in Russia*, Rusnano, 6 février 2012.
[111] *EADS and RUSNANO to Join Forces in the Nanotechnology Field*, Rusnano, 27 octobre 2011.
[112] *Rusnano creates 'Nanotechnology International Prize' award*, Rusnano, 25 mars 2009.

IV.13.e Evolution of number of patents

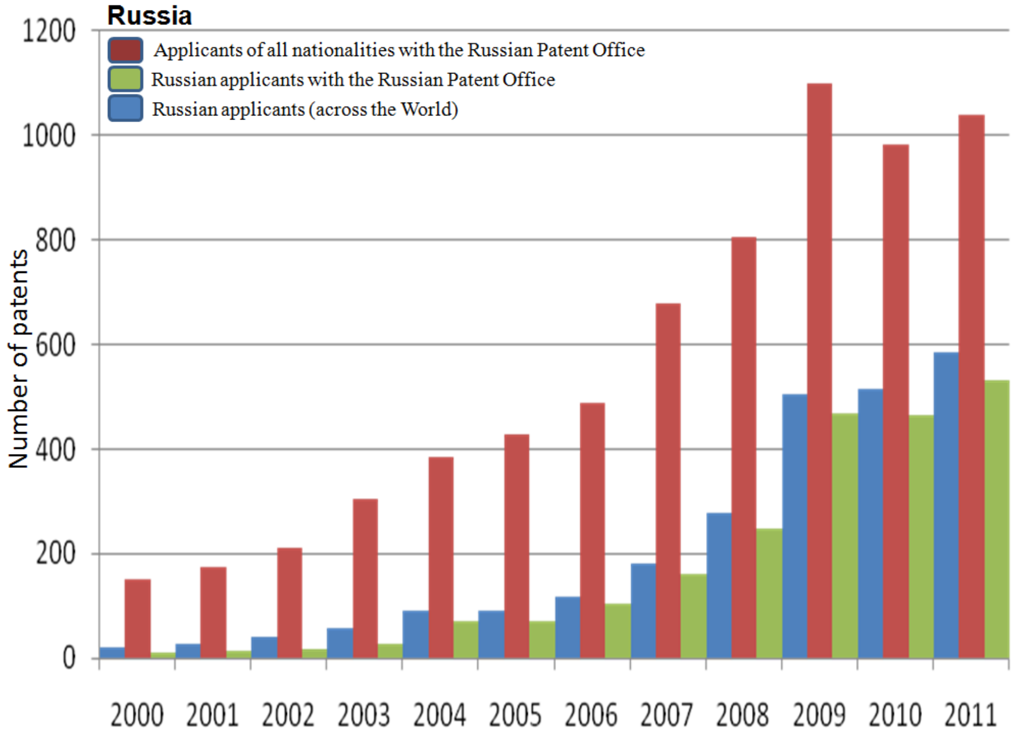

Figure 67. Patents published in Russia between 2000 and 2011.

The number of patents has been increasing steadily from 2000 to 2009, but remains low and place Russia in 7th position (Figure 67). The gap between Russian applicants and all foreign nationalities combined is wide, but has been decreasing significantly since 2011. In 2001, a large number of Russian patents were issued to applicants from the United States (27.5%) and Germany (21%). The number of Russian patents filed by France, although low, has been increasing steadily.

IV.13.f Types of companies

Russian industrial base

According to a statement by Vladimir Putin, nearly 1,000 companies were active in the nano-industry sector in August 2009[113].

[113] *Russian Nanotechnology R&D: Thinking big about small scale science*, FOI Swedish Defence Research Agency, Fredrik Westerlund, juin 2011.

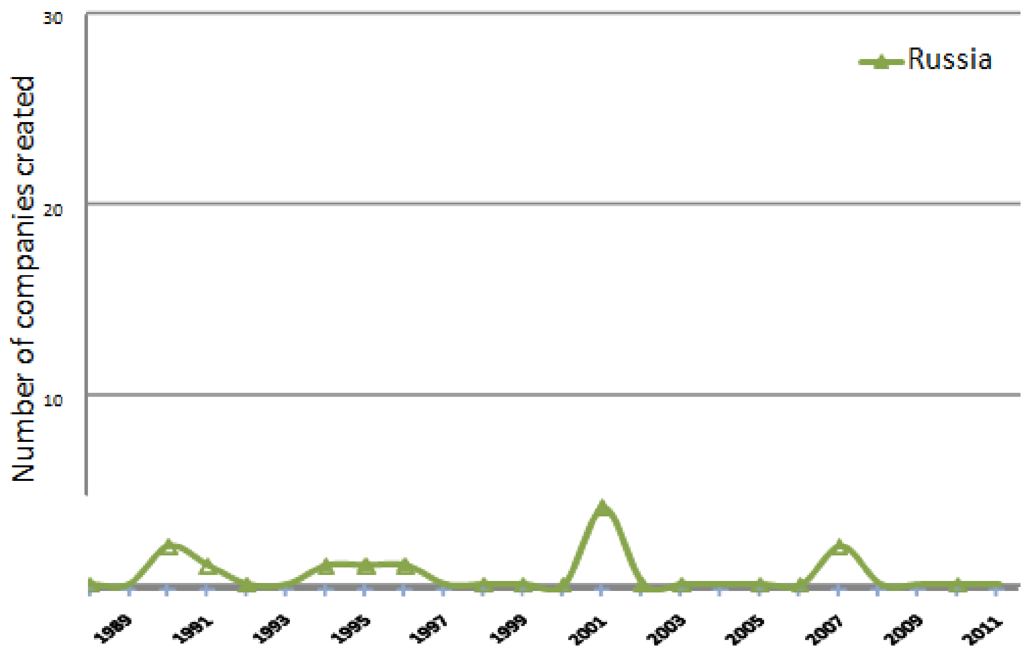

Figure 68. Creation of 12 nanotechnology companies in Russia from 1989 to 2011.

The number of Russian companies this study was able to access appears to be underestimated. Indeed, not only the number of companies created annually (Figure 68) but also the total number (only 15 companies including 12 created between 1988 and 2011) seems very low. It places Russia in 10th place. Identification of nanotechnology companies is made complicated by the country lack of organization, and the results found are far from Vladimir Putin's statement.

With this reservation about their total number, the types of companies in this study are shown in Figure 69.

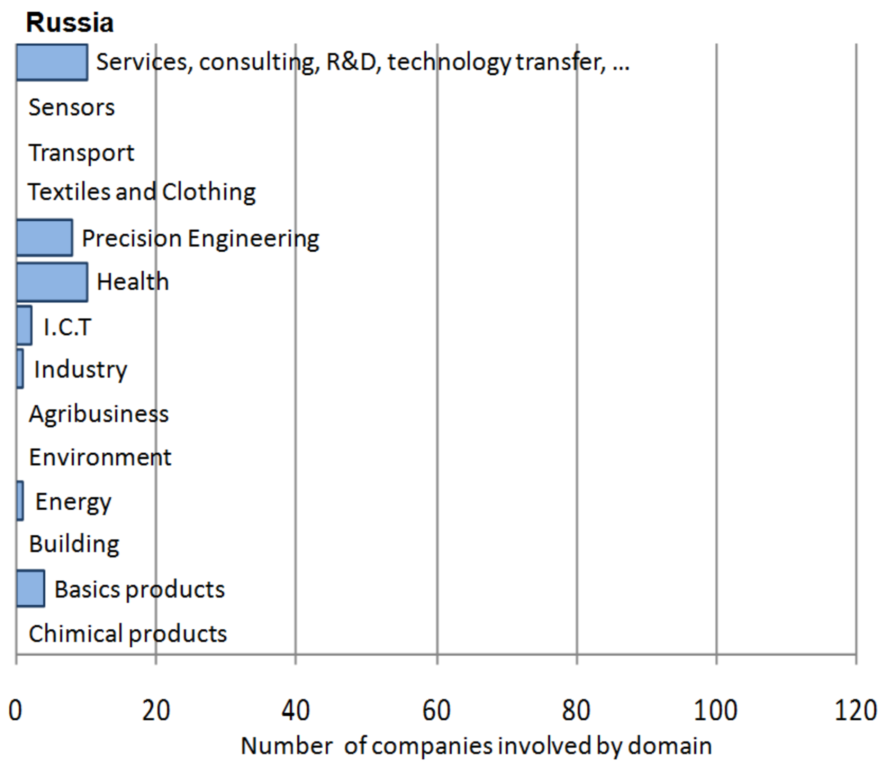

Figure 69. Distribution of the 15 Russian companies identified.

Keeping the above reservation in mind, medicine and precision mechanics are the best represented.

Conclusion

Russia has a world-class infrastructure for education and research. Russian laboratories have particularly extensive expertise in the field of physics of solids, crystallography and materials, and medicine. In recent years, this country has allocated very substantial financial resources to targeted federal programs in nanotechnology applications, including crystal growth, nanomaterials (especially powders and fibers), superconducting nanostructures, spintronics and memories. It also has multiplied collaborations with foreign laboratories, particularly in Europe and Asia.

The Russian government understands well that the extent of Russian achievements in the field of nanotechnology will define the place of Russia in the global economy, its level of competitiveness and its national security. This is why it also promotes the development of powerful industrial groups with foreign commercial partners, especially British, Americans, Finns, Koreans and Chinese.

Thus, having a gradual evolution which had made it close to the Western model, Russian research appears now to have stepped back to the old USSR model, with the government surrounding academic and industrial entities and managing relationships between them.

One may wonder whether the Russian government, which has a good infrastructure and many scientific brains, is investing heavily in new technologies to renew its weaponry.

Indeed, the civil / military ambivalence of nanotechnology can make military developments look like a legitimate approach to civilian application in order to revitalize the economy. The new innovation support structures also are a clear strategic military asset:

- Rosnanotech helps to foster links with foreign countries and to transfer advanced technologies to Russia.

- The various international fairs provide the opportunity for Russia to gather information about research topics in other countries.

- Partner-finding tools such as RTT or RFR [114] allow research centers and their skills to be mapped.

- Collaboration with foreign countries bring new know-how.

All the institutions which help technology transfer, together with the ambivalent character of "defense," **can promote renewal of armament to restore military power, and thus credibility as a world power.**

[114] RFR: *Réseau Franco-Russe de Centres d'Innovation Technologique* aims to offer a communication tool between Russian and French companies and transfer technologies organizations, so that they can share offers and requests for technology partnerships through a website (www.rfr-net.org).

RTTN: the *Russian Technology Transfer Network* was founded in 2002. It is an association of 68 Russian innovation centers from the 25 regions of Russia and CIS labeled Technology Transfer Areas. The RTTN is a tool for the effective dissemination of technological information as well as for finding partners for the implementation of innovative projects. The *Russian Technology Transfer Network* is a project initiated by the Obninsk Regional Innovation Technological Centre (RMCT Obninsk) and the Koltsovo's Innovation Centre (ICK) under the TACIS program (Project 9804 FINRUS) (www.rttn.ru).

IV.14 Taiwan

IV.14.a Master data

Population (2010)	23 millions
Area	36,008 sq. km
Average population density	640 residents/sq. km
GDP (2011)	$ 504.5 billon
GDP/inhabitant (2011)	$ 37,932
HDI (2011)	0.868

IV.14.b Taiwan's efforts

Taiwan, like mainland China, has made nanotechnology a priority area, supporting this sector of activity with many public investments. While mainland China's priorities are focused on nanomaterials, Taiwan has focused on semiconductors[115]. Taiwan's interest for this area comes from its perception that nanotechnology is a research-stimulating factor. This analysis is part of a broader vision of future commercial success, competitiveness and economic growth of the country.

Taiwan remains a very active nation in nanotechnology research[116] and is among the world's top countries in basic research[117]. Research is facilitated by access to world-class characterization infrastructure, such as the *National Synchrotron Radiation Research Center* (NSRRC).

Since 2003, Taiwan has been investing significant resources in the development of nanotechnology through two programs, with a view to finding industrial outlets:

- In late 2002, the Taiwanese authorities launched a wide-ranging nanotechnology development program called *Taiwan National Science and Technology Program for Nanoscience and Nanotechnology* (NNP). This program, amounting to over one billion euros has, in its first phase (2003-2008), developed academic capabilities in a dozen laboratories and research agencies and then, during the second phase (2009-2014), supported development of applications.Taiwan has also set up a *National Program on Nanoscience and technology*, with a budget of about $ 670 million, from 2003 to 2008, around $ 110 million per year, with the following main themes:

- *Basics research on the physical, chemical and biological properties of nanostructures,*
- *Synthesis, assembly and processing of nanomaterials,*
- *Development of manipulation techniques and fabrication of functional nanodevices,*
- *Energy related nanotechnology,*

[115] *Bulletin économique Chine*, Publications des Services économiques, Trésor D G, N°41 November 2011.
[116] Both academically and in government laboratories and in private industry.
[117] *Defense Nanotechnology Research and Development Program*, Department of Defense, December 2009.

- *Nano-biotechnology* [118].

Based on the first phase results, the authorities decided, after 2009, to accelerate the shift to industrial applications, with the support of a coordination structure led by the *Academia Sinica*, through the *National Nanotechnology Bridge Program*.

In 2010, leaders of the NNP program estimated that every dollar invested by the government for industrialization of nanotechnology program had generated $ 1.5 private investment, and the production value of Taiwan's nanotechnology products would more than double between 2012 and 2015, from $4 to 10 billion.

With the second phase of NNP (2009-2014), Taiwan also began to be interested in environmental, health and safety issues and standardization work by earmarking 30% of the amount allocated to strategic projects (nearly 17 million $).

The program revolves around the following themes [119]:

- *Academic Excellence, Research Program: Basic research on nanoscience, Synthesis, assembly and processing of Nanomaterials, Development of manipulation techniques and fabrication of functional nanodevices, Nano-biotechnology, Energy applications.Education Program.*
- *Core Facilities Program.*
- *Nanotechnology Industrialization Program: To enhance core facility and network, To speed up the development of nanotechnology, To develop and apply novel properties of nano-materials, To leverage the existing industrial knowledge and create new opportunities, To integrate new technical findings into the most competitive technologies and industries in Taiwan.*Furthermore, the Taiwanese Ministry of the Economy created in 2004 the Nanomark quality label to protect, on the one hand, consumers against products improperly claiming a nanotechnology content and, on the other hand, companies against unfair competition.

Finally, Taiwan is among the Top 15[120] of the world's major nanotechnology research center clusters, ranking 14th (see Figure 30).

The most significant Taiwanese research centers working on nanotechnology include *Academia Sinica*, *National Taiwan University*, *National Tsing Hua University*, the *Industrial Technology Research Institute* (ITRI) and the *NSRRC* synchrotron. The success of the Taiwanese management strategy is based on knowledge management, human capital and technological production.

[118] *Nanoscience & Nanotechnology Research Program in Taiwan*, Maw-Kuen Wu Director, Institute of Physics, Academia Sinica, Taipei, Taiwan and NNNP, TWAS 10th General Conference, 6 septembre 2006.

[119] 2011科技政策與創新前瞻研討會, Performance Measure and Efficiency Analysis of National Priority Science and Technology Programs in Taiwan, 台灣經濟研究院, 2011年6月7日.

[120] Source: extract from *L'internationalisation des systèmes de recherche en action. Les cas français et Suisse*, Ph. Laredo, J.-Ph. Leresche et K. Weber (Ed.), 2009, 24 p.

IV.14.c Priority sectors.

Overall, the Taiwanese industry is mainly based on high technology, key sectors being:

- Automotive et auto parts;Biotechnology;Photovoltaics;
- Renewable energies;
- Nanotechnologies;
- Semiconductors;
- Laptops;
- Communication and networks;
- GPS;
- Petrochemicals;
- Machinery;
- Maritime transportation;
- Yachts;
- Bicycles.

With respect to nanotechnologies, Taiwanese researchers excel in the following areas:

- nanofabrication and synthesis;
- characterization techniques;
- nano-bio devices;
- environment-health-safety;
- standardization work.

IV.14.d Defense and security-related programs

Taiwan mainly focuses its research on nano-optoelectronics, which offers many Defense opportunities exist and which can be displayed at the annual AFOSR fair[121]. However, information on defense-related activities is not easily accessible.

[121] Taiwanese Air Force.

IV.14.e Evolution of number of patents

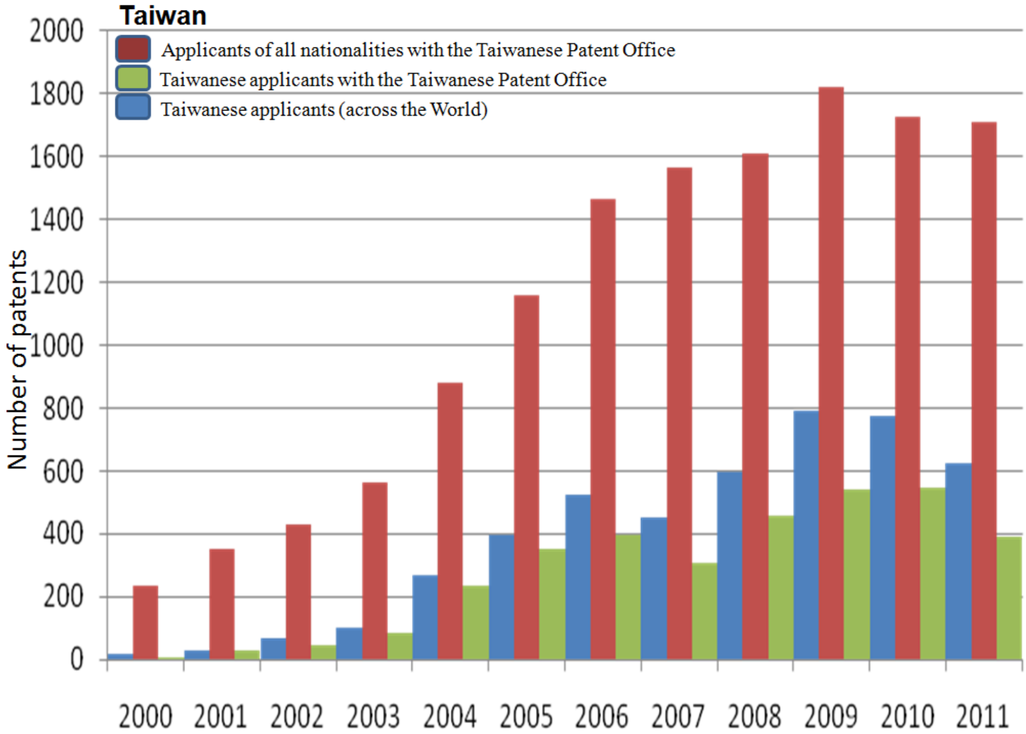

Figure 70. Patents issued in Taiwan between 2000 and 2011.

Taiwan ranks 6th in terms of patents filed, among the 13 countries in this study. But there is a significant gap between the number of Taiwanese applicants and of all other nationalities (Figure 70). This can be explained by the fact that Taiwanese companies rely on internal developments based on national and international cooperation [122]. The number of patents has grown steadily between 2000 and 2009. Filings by Taiwanese nationals did not start in earnest before 2004. This date matches the creation of the *Taiwan National Science and Technology Program for Nanoscience and Nanotechnology* (NNP). The program was dedicated to academic research for the years 2003 to 2008. Patent applications by Taiwanese are probably issued by academic research agencies and laboratories.

IV.14.f Types of companies

From the table below, it appears that Taiwan mainly attempts to acquire skills through international cooperation, and seems to emphasize very little its domestic R&D expertise.

[122] *Status of the Nano-technology and Applications in Taiwan*, Department of Invesment Services, MOEA, 2012.

ITEMS	No.	Industries	Source of Technology			Period for Manufacturers			Technology source from multinational technical cooperation or technology transfer
			Self	domestic	Oversea	R&D	Trial Production	Product	
Nano powder distribution, grinding and treatment technology	1	Emerging Company	●	●		●	●	●	
Nano-grade manufacturing technology	4	Semi-conductor, Chemical	●	●	●	●	○	○	Motorola, Philips, AMD, Infineon, ITRI
Nano-detection/analysis	1	Emerging Company						●	Service providers
Nano-detector instrument	2	Instrumentation	●		●	●	●	●	Oversea product agents
nanopowder	4	Chemical, Ceramic	●	●	●	●	●	●	ITRI, Oversea product agents
carbon nanocapsule	2	Chemical	●	●		●			ITRI
chemical/Mechanical grinding fluid	5	chemical, Metal	●	●		●	○	○	Academic Sinica, ITRI
Photoresist	4	Chemical, paint making		●	●	●	○	○	ITRI, Japan, TSMC, Brewer Science
Nano-composite material	15	Chemical, petrochemical, textile, electronic, emerging companies	●	●	●	●	○	○	ITRI, AMT Co. Canada
High dielectric material	1	Electronic material		●		●	●	●	ITRI
Nano IC Soft PCB	1	Emerging Company			●	●	●		Japan
Optical thin film	1	Chemical		●		●	●		ITRI
Magnetic resistance RAM (MRAM)	2	Semi-conductor, Chemical		●	●	●	●	●	ITRI , BJAST China
Nanotube emission displayer	2	Optoelectronics, electrical machinery		●	●	●	●		ITRI, domestic universities
Organic light emitting device displayer	2	Optoelectronics			●	●	●	●	Cambridge display tech. (CDT),UK and Kodak
High density optical disk	1	Optoelectronics		●		●	●		National Taiwan University
Electromagnetic insulator film	1	Chemical	●	●	●	●	●	●	ITRI and USA
Coating	2	Paper industry, emerging company	●			●			ITRI
Nano-grade ink-jet pigment	5	Chemical, electronics		●		●	●		
Bathroom facilities	3	Bathing room equipment, ceramics	●		●	●	○	○	ITRI
Antibacterial, deordering photoresist product		Consumer products, emerging companies		●		●	○	○	Japan, Academic Sinica
Functional fiber, textile products	1	Chemical, petrochemical, textile	●	●	●	●	○	○	Deputy for oversea products
UV resistance thermal insulating paper for automobile	1	Automobile Material	●			●	●		ITRI
Cold cathode fluorescent light tube	1	Optoelectronics	●			●	●	●	
DNA-IC	1	Biotechnology	●			●			
Cosmetic and skin care products	4	Biotechnology	●	●		●	●		NCU, NTU
Medicine, health food	1	Biotechnology, medicine	●	●	●	●	○		APN Co. of USA
Nano-material electrical cables		wire and cables	●	●		●			Domestic Universities

Source: ITIS project, 2007/11

Figure 71. Nanotechnology Development Strategy in Taiwan.

The total number of identified companies appear to be particularly low (15 companies), and does not necessarily correspond to reality (Figure 72).

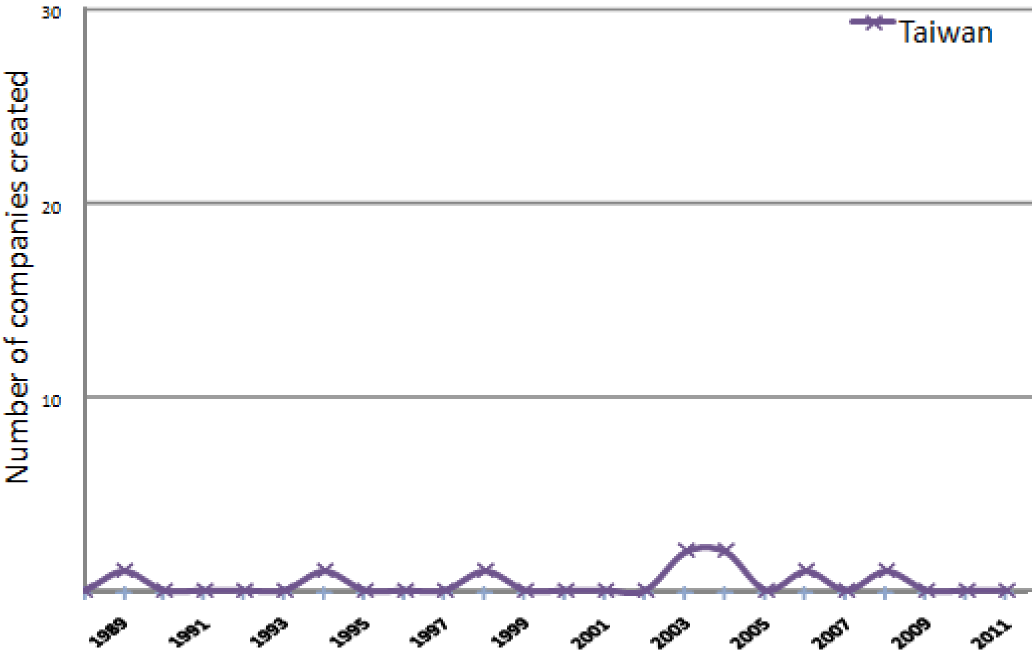

Figure 72. Creation of 9 nanotechnology companies in Taiwan from 1989 to 2011.

15 companies have been identified, including 9 created between 1988 and 2011. There was some activity, beginning in 2003, which corresponds to the government's investment at the time, then very low activity became non-existent in 2009. The second phase of the *Taiwan National Science and Technology Program for Nanoscience and Nanotechnology* (NNP), from 2009 to 2014, dedicated to industrial development, appears to not yet have had the desired effects on nanotechnology company creation.

Development of nanotechnology in Taiwan has been bootstrapped by the semiconductor industry. Companies created are representative of this investment by the electronic component industry[123]. In terms of income and investment figures, large electronics companies (TSMC, ASE, UMC, Mediatek, SPIL, etc.) account for the bulk of the activity (97% of investments in 2007). In terms of number of companies, the traditional sector (paint, textiles, ceramics, metal, mechanical engineering, paper) is the most represented (70% of existing companies), but it accounts for only a small share of nanotechnology investments.

With the abovementioned reservation about number, types of Taiwanese companies are shown in Figure 73.

[123] For example, in 2011, TSMC has started production of 28nm semiconductors (for this production, the company was awarded the Green Classic Award by the Ministry of Economy).

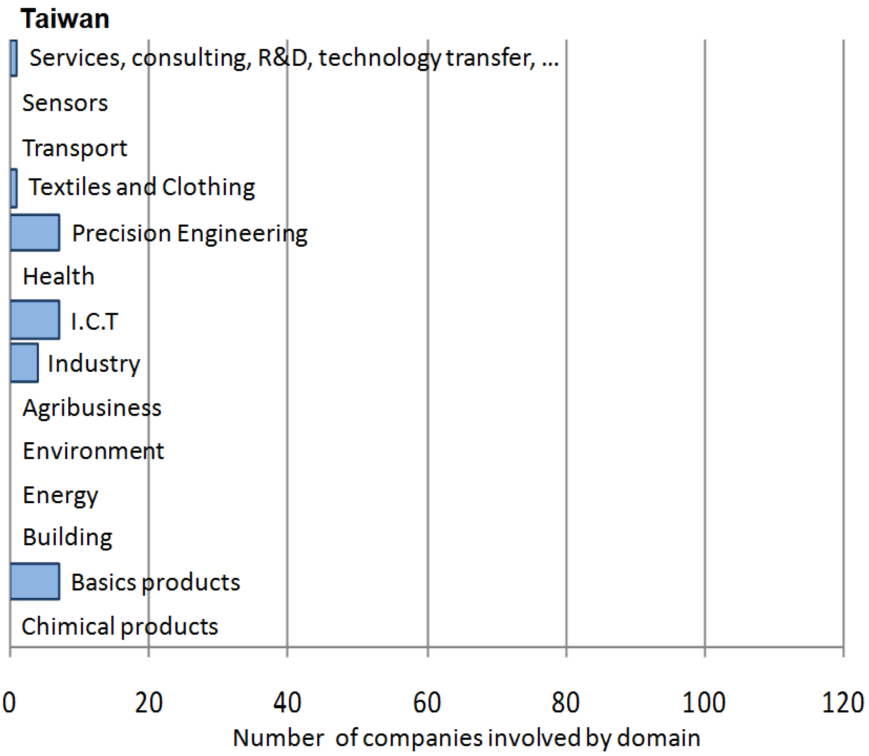

Figure 73. Distribution of the 15 Taiwanese companies identified.

Keeping the abovementioned reservation in mind, the ICT, precision mechanics and commodities sectors are better represented.

Conclusion

Very active in nanotechnology research, Taiwan has invested significant resources in their development through two national programs. The country also relies, in large part, on multinational cooperation and technology transfers.

Conclusion

Nanotechnologies are a key element of future technologies. They are the natural evolution of microtechnology and allow progress to be achieved in all areas. Not to be significantly present in this field would lead to becoming dependent of the countries which will master these technologies. It would also contribute to de-industrialization of France, thus also increasing even more its dependency to other industrial powers. This is true for the civilian sector, and this also true in the field of defense.

This study shows that competition in the field of nanotechnologies is global and robust. France needs a collective approach to research, rather than scattering our resources. To be internationally competitive, a critical mass in the three nanotechnologies key areas is necessary: characterization, modeling / simulation and manufacturing. Technology centers are a big step to that end, and that effort must be amplified.

To irrigate the industrial base commercializing what research has achieved, a chain from basic research to applications and technology transfer is necessary. Each link must be closely connected to the previous and the next ones. Government initiatives must promote and help this linking. Basic research must enjoy creative freedom, because no one knows what will be needed tomorrow, and innovations cannot be programmed. Applied research should focus on activities allowing industrial development, through strong links between laboratories and industry, through adequate funding at all stages of development, especially to support the growth of start-ups.

In terms of international competition, the speed of innovation is critical.

In this study, we have tried to identify for 12 countries and France, scientific and technological skills, and industrial capacities, in various sectors where nanotechnologies are present. We have focused on the ten having a strong potential the development of military or security applications.

With respect to for France, one can be optimistic. Government efforts in the last ten years are beginning to bear fruit, and this is expected to continue in the coming years. Concentration in one place of education, research and industrial facilities is essential to prepare for the future. This is what is taking place in the Major Technology Centers. However, one should be aware that there is still a long and difficult path forward, and that evolution is slow. There are often thirty years between a research result and products available in stores. Patience and perseverance are necessary.

This conclusion is a brief summary of the report with some general remarks. A detailed conclusion, and several recommendations as well as an analysis of the situation of nanotechnologies in France and the 12 other countries studied are available in the restricted version of this report.

Annexe 1 : Germany

Appendice 1 : Fraunhofer Alliance Nanotechnologie

Nanomaterials / nanochemistry

IAP **Fraunhofer-Institut für Angewandte Polymerforschung in Golm**

Tissue, cells, blood cells - biological material provides numerous models for polymeric nanosystems. Synthetic polymers designed according to biological construction principles are therefore excellent carrier for active pharmaceutical ingredients (drug carrier). By providing these polymeric nanoparticles with specially tailored surfaces and structures, they can be directed to specific sites in the body (drug targeting).
Nanocomposites are a new material class in the plastics sector that will decisively influence material adaptation and material optimization in the future. Polymeric nano- or microparticles of uniform shape and size, such as are obtained by emulsion polymerization, can be organized into highly ordered, crystal-like structures.
Birefringent film components with light-modulating properties are key elements in display technology or technology fields such as sensor technology or optical measuring technology.
Block copolymers are the basis for macroscopically homogeneous polymer alloys with a nanoscale sub-structure.
Details of the Institute's expertise

ICT **Fraunhofer-Institut für Chemische Technologie in Pfinztal**

Powder particles, particles or structures having dimensions within the nanometer range are the center of attention of the interdisciplinary nano technology at the ICT.
Details of the Institute's expertise

IFAM **Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung in Bremen**

Most of IFAM's activities in the area of nano technology concern the interface between the surface of the nanoparticles and the polymer matrix. These activities include the manufacture of metallic nanoparticles, the surface modification of a wide range of nanoparticles, the compounding of nanoparticles with matrix polymers and the characterisation of nanocomposites right through to the development of new analytical methods. Other key areas of work concern surface and thin film technology and relevant analysis.
Details of the Institute's expertise

IKTS **Fraunhofer-Institut für Keramische Technologie und Strukturkeramik in Dresden**

Sub-µm-and nano-technologies for transparent ceramic components exhibiting highest strength, hardness and wear resistance together with an extreme thermal and chemical stability
Details of the Institute's expertise

ISC **Fraunhofer-Institut für Silicatforschung in Würzburg**

The main focus of the Fraunhofer ISC is the production of nanomaterials. The sol-gel technology plays an important role for the manufacture of inorganic nano-scaled structure e.g. antireflex coating of glasses and the production of interference filters. Another nanomaterial are the inorganic-organic hybrid polymers (ORMOCER®e). With these polymers nano-scaled structures for microelectronic could be produced. Besides permeable hollow fibers inorganic hollow fibers (SiO_2) with nanopores can also be fabricated, which show high gas separation. Functionalized nanoparticles as filler and carrier material complete the nano-scaled material range.
Details of the Institute's expertise

IVV **Fraunhofer-Institut für Verfahrenstechnik und Verpackung in Freising**

The Fraunhofer IVV carries out R&D work on plastic packaging materials for food and pharmaceutical products and technical applications. The main focus of these activities is on developing and characterizing flexible polymer films which possess barrier properties or active additional functions. Our expertise includes film manufacture and conversion as well as carrying out tests on material properties such as permeation measurements and mechanical parameters.
Details of the Institute's expertise

IWM **Fraunhofer-Institut für Werkstoffmechanik in Halle and Freiburg i. Br.**

The main emphasis of IWM Halle and Freiburg in nanotechnology lies in the development and qualified use of functionalized nano structured materials for biotechnology such as nano-structuring by microsystem focussed ion beam techniques and surface functionalization of nanoporous membrane layers by enzymes.
Details of the Institute's expertise

IWS **Fraunhofer-Institut für Werkstoff- und Strahltechnik in Dresden**

With respect to thin films produced by PVD, CVD or laser processing, our scientists have a wide range of experiences. The nanostructuring of tetragonal-amorphous carbon films by Scanning Transmission Microscopy (STM) enables, e.g., information storage with extremely high storage density up to > 10.000 Gb/in2 and extreme long-term stability.
Details of the Institute's expertise

Nanooptics / nanoelectronics

ENAS **Fraunhofer-Institut für Elektronische Nanosysteme in Chemnitz**

The Fraunhofer Institute for Electronic Nano Systems ENAS in Chemnitz focuses on research and development in the field of smart systems integration by using micro and nano technologies together with partners in Germany and overseas, especially in Europe and Asia. Derived from the future needs of the industry Fraunhofer ENAS focuses on high precision silicon MEMS und NEMS (micro electro mechanical system und nano electro mechanical system), polymer based low-cost systems, RF MEMS, MEMS/NEMS design, development and test, wafer level packaging of MEMS and NEMS, green and wireless systems, metallization and interconnect systems for micro and nano electronics as well as 3D integration, process and equipment simulation, reliability and security of components and systems, printed functionalities.
Details of the Institute's expertise

IISB **Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie in Erlangen**

A technology which is used and enhanced besides the conventional lithographic structuring methods is based on the application of ion- and electron beams in a scanning force probe.
Details of the Institute's expertise

ISE **Fraunhofer-Institut für Solare Energiesysteme in Freiburg**

The Fraunhofer ISE is engaged in the field of organical and dye solar cells with new concepts and production technologies as further developments this novel photovoltaic converter. Besides the comprehension of optical absorption- and electrical transport processes is a matter of the further

development of nano scaled semiconductor materials and the conception of light management of microstructures. These concepts could be transformed to the field of displays. Another focus is the investigation of optically variable layer systems based on electro- and photo-chromatic material systems. Besides the basic research on these systems production technologies will be developed for large area manufacturing with these systems. **Overview** | **Details "Dye- and Organic Solar Cells"**
Details "Material development " | Details "Nanostructured Device Architectures"

Nanoprocessing / handling

IFF **Fraunhofer-Institut für Fabrikbetrieb und -automatisierung in Magdeburg**
Starting from the know-how already available and the experience in classical robotics, sensor technology and development of very fast controllers, new drive systems and tools for precision positioning up to the nanometer range are developed.
Details of the Institute's expertise

ILT **Fraunhofer-Institut für Lasertechnik in Aachen**
Laser and photon-based processes play an ever-increasing role in the production of nanotechnology products and lead to more flexible, cost-effective manufacturing solutions. Examples are laser processing of nanoparticulate films, the production of deterministic periodic surface structures by multibeam interference, multi-photon nano-drilling as well as lithography with extreme ultraviolet (EUV) radiation. Also in the area of metrology and diagnostics, laser-based processes open up new possibilities. For example, this could be the spectral analysis of airborne nanoparticles, the measurement of film thicknesses on the nanometer scale using LIBS (Laser-Induced Breakdown Spectroscopy) or EUV microscopy. In addition, Fraunhofer ILT develops customized beam sources for nanoscale applications. These include 13 nm sources for nanolithography and high-power ultra-short pulse lasers for nanostructuring. Furthermore, ILT is active in the field of the designing and manufacturing plasmonic components for nanophotonics.
Details of the Institute's expertise

IPA **Fraunhofer-Institut für Produktionstechnik und Automatisierung in Stuttgart**
As your partner for contract research we develop and optimise solutions for different tasks in engineering sciences. In the range of coating technologies processes with high process reliability and reproducibility in coordination between material development and coating process are formed. Thereby planning, developments, modelling and simulations up to implementations suitable for production are in the front.
Details of the Institute's expertise

Nanobiotechnology

IGB **Fraunhofer-Institut für Grenzflächen- und Bioverfahrenstechnik in Stuttgart**
The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB offers R&D solutions in the fields of health, environment and technology. Our competences comprise interfacial engineering and membrane technology as well as biotechnology, cell biology and bioprocess engineering. We offer solutions from market analysis through research & development until the finished product.
Details of the Institute's expertise: Cytokine-functionalized Nanocytes®

ITEM **Fraunhofer Institute of Toxicology and Experimental Medicine ITEM in Hannover**
ITEM has been investigating for more than 25 years primarily the toxic mechanisms and effects of inhaled substances in the respiratory tract. Research contracts are conducted for the pharmaceutical and chemical industry as well as for public sponsors. In the last decade, pharma research competencies have been enlarged continuously. Besides molecular (omics methods), preclinical and clinical pharma research (focus: allergy and asthma research), toxicological investigations on occupational and environmental issues and consumer protection are of crucial importance. A long-term competency is existing in the characterization and toxicological investigation of particle and fiber aerosols. For man-made mineral fibers, a standard test analyzing the biopersistence in vivo has been established. The actually discussed issue of the toxicological assessment of engineered nanoparticles has initiated a new research topic "nanotoxicology". Within the Fraunhofer nanoparticle alliance a battery of in vitro assays will be established that can help the producers to characterize rapidly and at affordable costs the toxicological potential of new nanoparticles before marketing the products.
Details of the Institute's expertise

New equipment / methods

IZFP **Fraunhofer-Institut für zerstörungsfreie Prüfverfahren in Saarbrücken**
The department of basic science at Fraunhofer IZFP deals with new test methods to develop the error detection and characterization of modern materials, also nanomaterials for future relevant aspects. Particularly, an ultrasonic force microscope for investigating nanostructures was developed.
Details of the Institute's expertise

LBF **Fraunhofer-Institut für Betriebsfestigkeit und Systemzuverlässigkeit in Darmstadt**
The main competence of Fraunhofer LBF is the testing of materials, components and systems with respect to structural durability and system reliability. Therefore, it is at the end of the value added chain but it is of increasing importance to incorporate aspects of reliability into nanomaterials already at an early stage.
Details of the Institute's expertise

Technology transfer/ consulting

IAO **Fraunhofer-Institut für Arbeitswirtschaft und Organisation in Stuttgart**
The Fraunhofer IAO deals with current questions in the field of management technology. The nanotechnology holds an innovation potential for many seminal industrial applications. The environmental and power technology benefits from the tiny all-rounder. The nanotechnology offers various possibilities of application, e.g. supply of drinking water, saving of valuable resourses and climate protection.
Details of the Institute's expertise

ISI **Fraunhofer-Institut für System- und Innovationsforschung in Karlsruhe**
Relevant to industry, relevant to society – the Fraunhofer Institute for Systems and Innovation Research ISI investigates how technical and organizational innovations shape industry and society today and in the future. A trademark of the systemic approach is the integration of research disciplines and the construction of a network for innovations, together with clients and interested parties. With its expertise, experience and reports, ISI as one of the application-oriented research institutes in the Fraunhofer-Gesellschaft makes a contribution towards strengthening European competitiveness. For this reason, politicians, associations and enterprises utilize Fraunhofer ISI as a foresighted and neutral intellectual mastermind able to convey visions for decisions.
Details of the Institute's expertise

Appendice 2 : Specialized Agencies and Competence Networks

- DFG: resources for research agency.

- WGL: Leibniz Association of Community Centers, with the main institutes: Institut für Neues Materialien (INM) -Saarbrücken, Institut für und Festkörper Werkstoffforschung (IFW) -Dresden Institute for Polymer Research (IPF) -Dresden, Institut für Oberflächenmodifizierung (IOM) -Leipzig, the research Centre Rossendorf (FZR) -Dresden, the Ferdinand Braun Institut für Hochfrequenztechnik (FBH) -Berlin.

- HGF: Community of the Helmholtz centers (Defence), Research Centre Jülich and Karlsruhe-FZK-FZJ Research Center in Geesthacht GKSS-.

- MPG: Max Planck Society, with institutes Institut für Festkörperforschung - Stuttgart, Institut für Metallforschung -Stuttgart, Institut für Mikrostrukturphysik - Halle Institute for Polymer - Mainz.

- FhG: Fraunhofer Society, which brings together twenty of its institutions (Annex 1) on the following topics: nanomaterials / Nanochemistry - nanooptics / nanoelectronics - nanoprocessing / handling - nanobiotechnology - new equipment / methods.

- Caesar Foundation.

The "Offensive German future for nanotechnology" was devoted to this subject (launched in 2004). Based on intensive discussions with representatives of business and science, the objective of the support of the BMBF nanotechnology is to identify potential application by using research cooperation (declined in guiding Innovations) strategically oriented chain of value creation, and to avoid the imminent shortage of experts in relation to the level of education policy. For a large number of important industrial sectors in Germany, the future competitiveness of their products also depends on the development of nanotechnology and the disposal of the company to use these products. The lively dialogues by the BMBF on the opportunities and the risks taken at the ecological, health, social and policies are taken into account to ensure public relations open. Since the late 80s, the BMBF supports research in the field of nanotechnology in the programs "Materials Research" and "Physical Technologies." The focus was primarily on the preparation of nanopowders on achieving lateral structures on silicon and on the development of nano-analytical methods. The BMBF has also supported research in the context of other programs such as "The laser research" and "Optoelectronics". These supports are now deployed in all sectors of German industry, such as nanomaterials, production technologies, optical technologies, microsystems Techniques, Communication Technologies, nanoelectronics, nanobiotechnology, technical analysis and innovations, etc.

Annexe 2 : Brazil

Specialized Agencies and competence networks

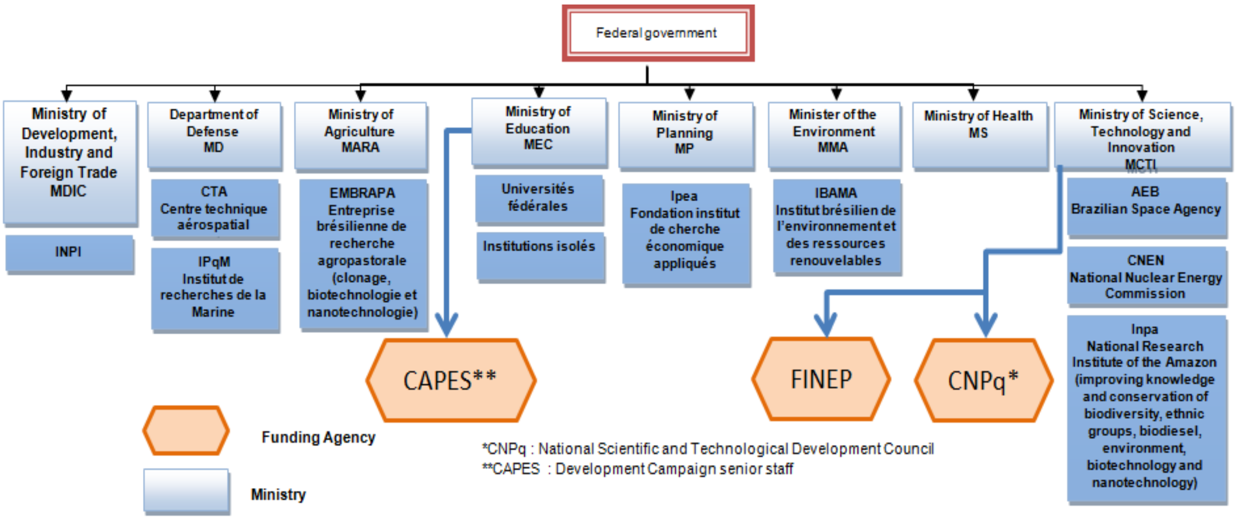

Figure 74. Flowchart of the Brazilian federal system.

The federal government estimates that the number of researchers in Brazil in 2000 for a full-time equivalent is around 49 000, of which nearly 57% have a PhD, equivalent to 1.3 researcher per thousand jobs, which is a very low average of 6.6 per thousand in OECD countries (6.8 per thousand in France). It is especially in the Southeast region that concentrates the bulk of Brazilian research teams: the only state of São Paulo employs approximately 35% of the national contingent of researchers in the public sector. The major problems to face in the future affect both the volume and sustainability of the resources allocated, the heterogeneity of the regional distribution of teams and the too modest contribution of the private sector.

Using the conventions of the French Observatory of Science and Technology (OST), we see that the Brazilian contribution to world science reaches 1.0% in 2001, while it was only 0.42% in 1989 . It is a constant and accelerating growth since 1994.

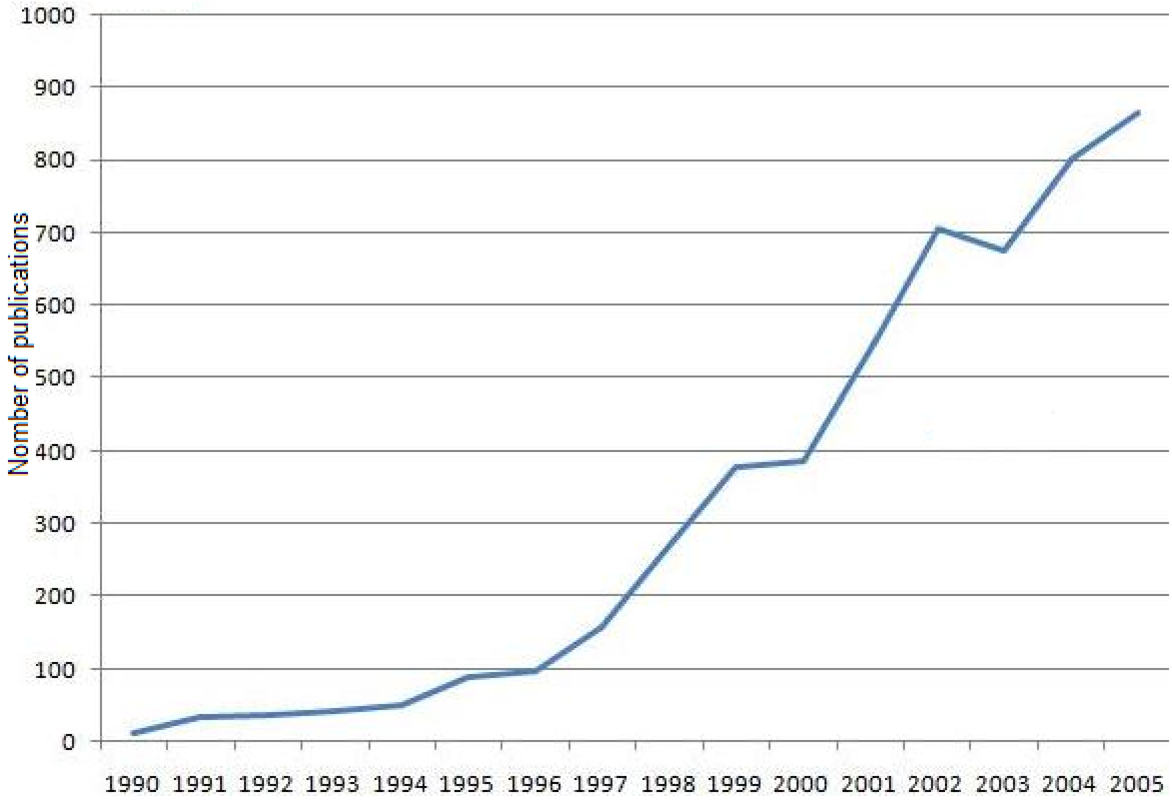

Figure 75. Evolution of the number of publication in Brazil from 1990 to 2005[124].

[124] *Nanotechnology in Latia America*, Luiciano Kay, 2006.

University of Campinas UNICAMP: LNLS Synchrotron Laboratory, Laboratory nanotechnology and solar energy laboratory on nanostructures and interfaces laboratory dielectric materials / optical and nanocomposites	Campinas	www.lnls.br www.ccs.unicamp.br/namitec
University of Sao Paulo: nanotechnologies and nanomaterials	Sao Paulo	www.usp.br/prp/nanotecnologia/
Agricultural research center EMBRAPA: national laboratory of nanotechnology in agriculture	Sao Carlos,	www.embrapa.br/english
Federal University of Rio de Janeiro: Instituto de Biofísica, Instituto de Física, Instituto de Macromoléculas, Instituto de Química e Programa de Pos-Graduação e Pesquisa de Engenharia COPPE. Coppe et l'Instituto deMacromoléculas	Rio de Janeiro	
INMETRO specialized in metrology and standardization of nanotechnology	Rio de Janeiro	www.inmetro.gov.br
Catholic University: multidisciplinary nanotechnology (physics, electrical engineering, chemistry, computer science, materials science, mathematics)	Rio de Janeiro	www.ica.ele.puc-rio.br/nanotech/main.asp
Federal University of Minas Gerais: carbon nanotubes and nanotechnology for aerospace industry ; the Chemistry Institute	Rio de Janeiro	www.ufmg.br/english
Federal University of Pernambuco UFPE: Nanophotonics and nanomolecules	Recife-Pernambuco	www.ufpe.br
Federal University of Amazonas UFAM: nanobiotechnology and nanoelectronics NEMS	Manaaus	www.ufam.edu.br www.suframa.gov.br/minapim

Figure 76. Major Brazilian nanotechnology research centers.

In October 2005 nanotechnology networks are restructured to form 10 networks composed of scientists, universities and research centers in different parts of the country.

Nom du réeaux	Coordinateurs	Participants
Nanophotonics Network (NANOFOTON)	Anderson Stevens Leônidas Gomes	UFPE (Federal University of Pernambuco), UFAL, UFS, IPEN, FATEC, UNESP, UNIVASF
Research network in Nanobiotechnology and nanostructured systems (NanoBioEstruturas)	Eudenilson Lins de Albuquerque	UFRN (Federal University of Rio Grande do Norte), UFMA, CEFET-MA, UFPI, UFC, UFPE, UFAL, UnB
Network of Molecular Nanotechnology and Interfaces	Oscar Manoel Loureiro Malta	UFPE (Federal University of Pernambuco), USP, UFRJ, UFS, PUC-RJ, UFPR, UFCG, UEPG, UNESP, USP/SCarlos, IPEN, IPT, UFRN, USP/RP, Universidade de Aveiro, Portugal, INMETRO, PQNano (Ponto Quantico Nanotecnologia)
Network of Carbon Nanotubes: science and applications	Marcos Assunção Pimenta	UFMG (Federal University of Minas Gerais), UFPA, UFMA, UFC, CDTN, UFLA, UFJF, UFF, UFRJ, UFPR, UNIFRA, USP, USP/RP, UNICAMP
Nanocosmetics network: from concepts to technological applications	Sílvia S. Guterres	UFRGS (Federal University of Rio Grande do Sul), UNIFRA, USP, USP/RP, UNICAMP, UEM, UMC, IPT, UCS, UFRJ
Scanning Electron Microscopy network: software and hardware	Gilberto Medeiros- Ribeiro	LNLS (National Laboratory of Synchrotron Light), UFRGS, UFSC, USP, UNICAMP, UFMG, CDTN, UFV, UFRJ, PUC-RJ
Research Network in Simulation and Modelling of Nanostructures	Adalberto Fazzio	USP (University of São Paulo), USP/SC, UNICAMP, UFSM, UFMG, UFU, UFRJ, UFF
Cooperative Research Network in Nanostructured Surfaces	Fernando Lázaro Freire Júnior	Fernando Lázaro Freire Júnior SOCIESC, UCS, EMBRACO, Clorovale
Nanoglicobiotechnology Research network	Maria Rita Sierakowski	UFPR (Federal University of Paraná), UFC, UNIFOR, USP (SP & SCa), UNIVALI
Nanobiomagnetic Network	Paulo César de Morais	UNB (University of Brasilia), UFG, USP-RP, USP, UFRJ, UFU, UNIFESP, UFMS, DNATech, FKBiotec, EMBRAPA, HRAN, FINATEC

Figure 77. Réseaux financés en nanotechnology par Rede BrasilNano.
Source : MCT website, Martins et al, 2007.

Annexe 3 : South Korea

Appendice 1 : Geographical distribution of activities

The provincial universities (excluding the regions of Seoul, Incheon, and Gyeonggi) benefit from NURI program of KRF, which aims to strengthen regional competitiveness based on a partnership universities, research centers, industry, NGOs and local governments. Since 2004, the government has financed the construction of 10 regional research centers (Daejeon, Jeanbuk, Gwangju, Chungbuk, Gangneung, Busan, Daegu ...). In 2010, these centers receiving up to € 11 million over a maximum period of 5 years. The Daedok cluster in Daejeon, by far the most active after Seoul, has 824 high-tech companies, including in nanotechnology, many research institutes, universities and industries. Concentration close to 20% of the country's research effort, it generated annual revenue of 7.18 billion euros in 2010. Gyeonggi Province (southern Seoul) account for its large number of foreign R & D institutions, because of its proximity to the séoulite megalopolis and significant investment in R & D by the government of the province (for France Institut Pasteur Korea, supported by the authorities of that province, and the french company Faurecia (2nd largest automotive equipment) for a project to create an R & D center for the development of applications for automobiles sold in the market Korean.)

Top 5 universities (KAIST, Seoul National University, Yonsei University, POSTECH, Korea University) emerging as major centers of scientific production in all rankings (number of the highest scientific publications).

Appendice 2 : National Research and Innovation System

The Ministry of Education, Science and Technology (MEST, formerly Ministry of Science and Technology, MOST until the reform of March 2008) acts as secretariat for the NSTC and acts as an inter-agency Central coordinating R & D public policies. MEST consists of two divisions, one for science and one for technology education. MEST is the largest R & D contributor public sector (31.9%), followed by the Ministry of Economy and Knowledge (MKE), around 29.3%, the Ministry of Defence (15.9 %) and the Ministry of Land and Maritime Affairs (5.2%). MEST, MKE and the Prime Minister ensure the monitoring, evaluation and coordination of public research institutes funded by the government (Government-sponsored Research Institutes, GRI). MEST is in charge of steering 24 GRI, which are mostly specialized institutes into a scientific discipline. 11 of them are directly controlled by the Ministry of Education, Science and Technology, to enable them to perform specific tasks directly related to the mandate of the Ministry. The other 13 GRI are placed under the supervision of the Korea Research Council of Fundamental Science & Technology (KRCF) that ensures their control.

Authority on Universities : The Ministry of Education, Science and Technology (MEST) is responsible for the formulation and implementation of education policies in line with the academic and scientific activities of universities. Universities are funded at 75% by the MEST, the remaining 25% are from local authorities and / or companies and tuition fees for students who remain very high in Korea. The budget MEST represents 31.9% of the total government budget in 2010 and 27.2% of its budget is spent on higher education. In 2009 Korea has about 3.5 million students of which 40 500 foreign and some 73 000 university professors to 42 "National Universities", 10 public universities and 353 private universities.

Funding Agencies : Korea has very high ambitions in terms of science and technology with the aim to raise the country among the top ten nations in terms of scientific output by 2012. This policy is reflected in particular by the scale of the resources allocated to R&D in South Korea with the objectives set at 5% of GDP by 2012. In order to increase efficiency and visibility in the use of these means, the 3 research funding agencies under the tutelage MEST were restructured to form the National Research Foundation (NRF), which opened June 25, 2009. There are a dozen other agencies for funding and managing research programs under the supervision of other ministries in Korea. Under the supervision of MKE, ITEP (Korea Institute of Industrial Technology Evaluation and Planning) is the funding agency for technological projects. Four other ministries have research funding agency, but these come with much lower budget than in the NRF (Ministry of Land, Transport and Maritime affairs, 2 agencies with € 200 million, Ministry of Food Agriculture Forestry and Fisheries, 55 million euros, Ministry of Health and Wellfare, 110 million and Ministry of Environment, 68 million euros in 2009). Public spending on R & D is as follows: 53.4% in state projects, 26.6% of research institutions (including 10.7% in GRI), 15.5% in universities, 3 5% in infrastructure, 1% for international cooperation and research policy.

South Korea has 37 public research institutes in Science and Technology (GRI), 11 of which are under the direct supervision of the MEST. The GRI receive 42.4% of total public funds, national laboratories, universities 9.7% and 22.6%. There are also private research institutes, some of which are among the best in the country.

KIST (Korea Institute of Science and Technology) is the oldest Korean research institute. Founded in 1966, it is a technological institute and multidisciplinary character, which employs nearly 650 people, including 420 researchers. It has a branch in Saarbrücken, Germany, which employs 49 people and serves as a rear base for cooperation with Europe.

KARI is also the space agency and defines the guidelines of the Korean space policy. With a budget of around 320 million euros and a workforce of 670 people (June 2009), KARI is responsible for the implementation of spatial large programs (KSLV, space center, KOMPSAT). He has expertise in aviation since it develops UAV programs (unmanned aerial vehicles) and light transport aircraft. It has signed cooperation agreements with 19 organizations from 13 countries (Dec.2007).

The KRIBB (Korea Research Institute of Bioscience and Biotechnology), the main public research institute in Korea and biotechnology sciences, employs about 900 people, including 200 permanent researchers. The institute incorporates the same premises basic and applied studies in genomics, proteomics, biotechnology nanoscale, cell biology, biomaterials and pharmacy. It is engaged in cooperation with 68 institutions from 18 countries and set up joint laboratories with China, Israel and the UK.

The ETRI (Electronics and Telecommunications Research Institute), the "armed arm" of the public development into ICT for of the 9 Korean strategic technologies for the computerized Society "839" and "New IT Strategy". It is structured into divisions corresponding to each of these projects. ETRI has approximately 2,000 researchers, 1,500 international publications and deposited about 800 international patents by year via the PCT.

Companies have fully funded research institutions on their own funds, which play an important role in National Korean R&D. Of the 83 000 employees of Samsung Group in Korea, 38% are employed in R&D. The main private institute is the Samsung Advanced Institute of Technology[125] (SAIT) and employs 1280 people. Serving the Samsung Group, SAIT is one of the most important research institutes in Korea. In 2004, he invested 194 million in R & D. Samsung launched its project Nano City "Samsung Digital City", born in October 2009 and centered on semiconductors, in the cities of Giheung, Hwasung and Onyang. This initiative creates a real working environment in these cities where several hundred employees of the world's leading technologies regroups together [126].

Korean university system is very competitive and very expensive for families. Universities are in strong competition:

- KAIST (Korea Advanced Institute of Science and Technology), University under the supervision of MEST, located on the campus of Daejeon since 1991

- POSTECH (Pohang University of Science and Technology), partly funded by the company Pohang Iron and Steel Company (POSCO), POSTECH has become one of the

[125] Samsung Advanced Institute of Technology (SAIT) : www.sait.samsung.co.kr

[126] *AROSMIK, Samsung lance son projet de Nano City*, encoreedusud.com, 8 avril 2010.

largest universities of Korea (ranked 2nd in 2008): 3,000 students, 800 researchers and 230 permanent professors, 1000 SCI referenced publications per year,

- SNU (Seoul National University), 1st National University in South Korea, 22,000 students, 5,000 SCI referenced publications per year,

- Korea University, 30,000 students, numerous scientific articles with prestigious universities such as Yale and Cambridge University.

Appendice 3 : Collaboration in the R&D sectors

The framework of the Science and Technology Cooperation France / South Korea is the Hubert Curien Partnership signed on 15 June 2009 in Paris (eg PAI) "STAR". It funds the mobility of researchers for thirty projects jointly selected on criteria of scientific excellence by both parties. It's an exchange tool for the networking of scientists and non for collaborative research itself. Program management is entrusted to the National Research Foundation for the Korean side and the Embassy of France in Korea. The two sides agreed to continue to support the STAR partnership and expand the sectors supported by it. The PHC Star will provide support through aid to the exchange of researchers in the most innovative projects in the areas: new materials and nanotechnologies - life sciences, health and biotechnology - science and information technology and communication - basic science - aeronautics and space - social sciences - environmental sciences. Today; there is no direct funding mechanism for joint research projects. CNRS has an old and well-established position in the cooperation mechanism, due to two agreements signed in 1991 and 2001. The Ecole Polytechnique is also well established in Korea and launched in September 2006, a teaching and research chair in partnership with Samsung Electronics, on the topic of nanotechnology applied to flat screens and unconventional electronic. The "Nanodix" chair is the fifth established by X with industrial partners (Thales, EDF, Renault and Dassault, Lafarge and now, Samsung Electronics) and the first with international vocation.

Two joint laboratories, whose structure is based on the concept of International Associated Laboratory (LIA) of the CNRS, were created:

The Centre for Photonics and Nanostructures (CPN) is a joint laboratory set up in June 2006. This combines 5 French and Korean major institutional partners, with KIST and KAIST on one hand, CNRS, Université Joseph Fourier in Grenoble and the Ecole Centrale de Lyon on the other hand. This structure, led by two coordinating teams in Grenoble and Seoul brings together world-renowned Korean and French teams and associated them with a Korean national technology platform (one of two national centers to support nanotechnology research), the Korea Advanced Nanofab Center (Kanc). LIA was awarded by the MEST funding of about 1.15 million annual euros, for a period ranging from 3 to 9 years, under the Global Research Laboratory program. 6 projects were funded in 2009 on the same program, 4 with the United States, one with Japan and one with Switzerland. One example of success is the development of a nano laser by a research team composed of South Koreans (Korea University) in French (Institute of Nanotechnology in Lyon) and Americans (Harvard University), which would allow term to develop efficient optical computers and low energy consumption. An optical computer is a machine that uses photons instead of electrical current to transport data. This has several advantages, the main one being a data transmission rate 10 times greater than that of electricity. An optical computer also consume less power and could be much more compact by eliminating bulky electronics. The NRF (National Research Foundation of Korea), which financially supports research, said that the creation of such machines would be possible within ten years [127].

[127] *Une équipe de chercheurs met au point un nano laser*, Julien Nicoletti, BE Koréa number 52, French Embassy in Korea / ADIT, 27 September 2010.

Another success of this cooperation is the miniaturization of actuators [128]. The DNC (Digital Nanolocomotion Center, which is part of National Creative Research Initiative Program and KAIST) has designed an actuator of 1,2x1,3 mm^2 able to perform 7,200 movements of 12.3 nm per second. This component works by reproducing the non-linear movement of living organisms. In addition, it was realized a nano-displacement detector capable of detecting movements of 0,019nm. This is about 5 times more effective than existing detectors. These components have many technological applications in sensing, control, and manipulation of nano-bio-components. The DNC had recently developed nano-biochips and vibrators for separation of DNA qnd a digital mirror switch of 0,9x0,9mm^2 to control the weak photonic signal of optical transmissions. It also allows a high processing speed for very low signal loss.

Finally, a digital injector capable of projecting a liquid drop of 5.8 micrograms with a speed of 12 m / s for only 0.4 W was also performed. The applications of this tool in the field of portable printers are obvious, but the injector could also be used for the minisatellites positioning.

The «France-Korea Particule Physics Laboratory» (F-K PPL) created at the initiative of Physics National Institute for Nuclear and Particle Physics (IN2P3) as part of an agreement with KISTI brings together joint research activities in the fields of particle physics, the bioinformatics and e-science.

With China, successful cooperation topics are weather forecasting, biotechnology, new materials, environmental technologies, applied laser technology and the commercialization of advanced technologies. The two countries established four joint research centers in Korea and two in China.

Britain signed a 1st Science and Technology Cooperation Agreement with South Korea in 1985. The two countries have seletedthe 9 following themes: optics, biotechnology, ICT, gas hydrates, creative industries, energy, environment, space, nanotechnology. Six joint centers have been set up since 2004, including 2 with the University of Cambridge (respectively with KAIST in optoelectronics and ETRI in nanotechnology, biotechnology and ICT). Cooperation develop in the field of neuroscience and new energy.

South Korea joined the OECD in 1996. Since, it participates actively to the various bodies, including the Committee for Scientific and Technological Policy (CSTP). Several regional centers have their implantations in Seoul: International Vaccine Institute, APCIT (Asian Pacific Centre for Transfer Technology). Several Korean teams are funded by multilateral programs of the French Ministry of Foreign Affairs, within the framework of Franco-Asian research projects in the field of ICT (program "ICT-Asia").

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[128] *Recherches sur la Nano-Locomotion en Corée*, Jérôme Pinot, BE Koréa 20, 14 November 2002.

Annexe 4 : United States

Appendice 1 : National Research and Innovation System

The American Research and Innovation System is a system in which different levels are well separated. The orientation of science policy is define by the White House's Office for Science and Technology Policy (OSTP). Established in 1976, this body has the task of adviser President on all aspects related to science and technology. OSTP supervise and evaluate federal investments in research and innovation to ensure proper orientation of science policy. These guidelines are reflected in the development of research funding programs within federal agencies and the various "departments", the most famous are the National Science Foundation (NSF), the Department of Energy (DOE), the Department of Defense (DOD) and the National Institute of Health (NIH). These agencies aim to translate the political guidelines into call for proposals to fund research.

The National Research Council (NRC) is the the evaluating body of NNI actions. It recognizes that the program is very young compared to the time scale required for the development of technological revolutions (20 to 40). NSC stressed that the NNI should register on the long-term goals and objectives it supports are only achievable in the long term. It notes that to bear fruit, the NNI investment must be maintained. A key aim is to continue building national advanced infrastructure in this area while the costs of the necessary instruments can not be borne by a single organization. The NNI has also motivated the agencies to set their own priorities, creating dedicated research programs and to raise themselves new resources. The program should continue to intelligently articulate goals over the long term and those on the short term, without sacrificing the first in a purely utilitarian logic of research. Finally, the NRC notes the positive contribution that represent strategic foreign researchers. It calls to continue to attract the best talent in the United States and carry in that particular attention on the immigration requirements of students and scientific staff. The years 2007-2010 were particularly devoted to consolidate the programs and infrastructure, by providing them with sufficient staff and an update of the instruments with the aim to achieve maximum use of existing infrastructure. The change of administration in 2009 (Obama) has led to give new impetus to the program [129]. The lack of authority of the program on the agencies is always a central difficulty and seen as a weakness. The United States are worried about increasing their supply of gray matter.

[129] *Report to the president and congress on the third Assessment of the National Nanotechnology Initiative*, President's Concil of Advisors on Science and Technology PCAST, 12 March 2010.

Appendice 2 : Geographical distribution of activities

The map in Figure 80 and the list established on the website of the NNI [130] showing the highest distribution of many infrastructure on the whole territory. The DoE has created five dedicated centers into the national laboratories, the Nanoscale Science Research Centers, and has just approved 46 Energy Frontiers Research Centers[131]. The DoD has created an Institute for Nanoscience in the Naval Research Laboratory Centers[132]. The National Science Foundation funded 27 Materials Research Science and Engineering Centers, 14 centers in the National Nanotechnology Infrastructure Network or ten Nanoscale Science and Engineering Centers[133]. The National Institute of Health, for example, set up eight Nanomedicine Development Centers and Nanotechnology Characterization Laboratory on issues of Nanotoxicology with the National Institute of Standards and Technology (NIST)[134]. NIST built the Center for Nanoscale Science and Technology and its NanoFab to work on the development of measurement instruments, norms and standards in the field of nanotechnology. Much of the infrastructure is open and there is equipment that can be used by researchers and industrial companies.

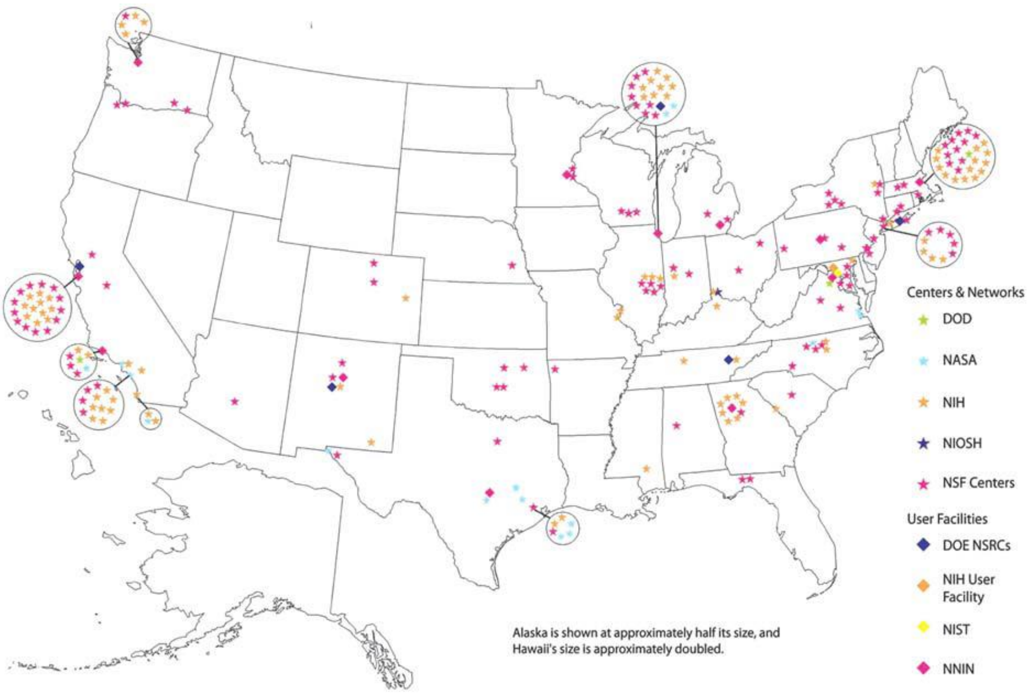

Figure 78. research centers, networks and "user facilities" funded by the NNI in 2007.

[130] NNI www.nano.gov
[131] Energy Frontiers Research Centers www.er.doe.gov/bes/EFRC/index.html
[132] Institut for Nanoscience du Naval Research Laboratory www.nrl.navy.mil/nanoscience/
[133] MSREC Network www.mrsec.org/centers et National Nanotechnology Infrastructure Network www.nnin.org
[134] List of Nanomedicine Development Centers – http://nihroadmap.nih.gov/nanomedicine/ et Nanotechnology Characterization Laboratory – http://ncl.cancer.gov/

The NNI has also helped to set up a wide variety of networks to transmit important information: the InterNano Forum National Nanomanufacturing Network that allows researchers to exchange information regarding the manufacturing of nanomaterials, the nanoHUB funded by NSF which includes online simulation tools accessible to the whole community[135]. The NIH has set up a network around the efforts on the treatment of cancer, the National Cancer Institute Alliance for Nanotechnology in Cancer. Regarding health issues, safety and environment, the International Council on Nanotechnology maintains on its website a number of published articles database[136.] Finally, on educational issues, it is possible to cite the Nanotechnology Center for Learning and Teaching (NCLT), useful to all levels of education to promote and publicize nanotechnology[137.] The goal for the next 10 years is to maintain the infrastructure and capitalize on their potential. The challenge of standards recalled that the regulation can become a barrier to open markets, and the US will be involved on the standards that open the way for innovative products and new markets.

[135] Internano www.internano.org et Le nanoHUB – http://nanohub.org/
[136] National Cancer Institute Alliance for Nanotechnology in Cancer – http://nano.cancer.gov/ and ICON – http://icon.rice.edu/
[137] NCLT Community – http://community.nsee.us/

Appendice 3 : Investisors List

In principle, there are three types of investors:

1. Those who focus on the end market rather than the underlying technology/science.
2. Those who focus on technology/science rather than on the market.
3. Those with vision assessment.

The pre-listed companies investors can be divided according to the stage of evolution of the company, ie starting from the beginning, middle or end. Currently, conditions in Europe are difficult to obtain investments in entities in start-up stage.

Applied Ventures 3050 Bowers Ave., P.O. Box 58039, Santa Clara
Venture capital funds from Applied Materials, Inc. a global leader in the field of nanofabrication technology solutions for the electronics industry. Its portfolio includes: ActaCell Inc. - next generation technology for lithium-ion batteries, Infinite Power Solutions Inc - ultra-thin, flexible, rechargeable micro-batteries lithium, Innolume - quantum dot lasers manufacturer of semiconductors, Nanomix - nanoelectronic detection company, Tera-barrier Films - high performance flexible barrier film.

Band of Angels
The earliest start-up funding agency. Its portfolio includes Espin Technologies Inc., founded with the mission to develop the technology to produce nanofibers and commercially based products nanofibers.

Draper Fisher Jurvetson
DFJ achieve its mission through its DFJ Global Network of funds associated with operations in the US, China, India, Korea, Vietnam, Russia, Europe, Israel, Brazil and Japan. Over the past 25 years, DFJ and its partners have supported more than 600 companies, and have led the way in emerging technology markets including the Internet, mobile communications, clean energy and health care. DFJ has been proud to support the achievements of the industry, including Baidu, Skype, Overture, Hotmail, Parametric Technologies, Focus Media, AdMob, Mobile365, EnerNOC, Tesla, SolarCity, BrightSource Energy, athenahealth, Epocrates, SpaceX and Synthetic Genomics.

Harris & Harris Group 1450 Broadway, 24th Floor, New York
It first became interested in nanotechnology in 1994 with an investment in Nanophase, who went public with the result in 1997. In early 2002, this group was convinced that nanotechnology had matured enough to deliver business flow robust for the indefinite future, began to focus exclusively on nanotechnology and microsystems. Its portfolio includes: ABS Materials Inc., Cambrios Technology Corp., Contour Energy Systems, Inc. Innovalight, Kovio Inc. Molecular Imprints Inc., Nanosys Inc., Nantero Inc.

Hatteras Venture Partners

Hatteras Venture Partners is a venture capital firm based in Research Triangle Park, NC, with a focus on biopharmaceuticals, medical devices, diagnostics, and opportunities related to human medicine including nano. Founded in 2000. With four funds, the company has more than $ 200 million under management.

Intel Capital 2200 Mission College Blvd. Santa Clara

Since 1991, Intel Capital has invested more than $ 9.8 billion in over 1,100 companies in 48 countries. Its portfolio includes: FulcrumMicrosystems, Inc. Nanosys, Nexplanar Corp, Xradia, Energetiq Technology Inc.

Livingston Securities, LLC Livingston Securities LLC, 825 Third Avenue, Second Floor, New York

Investment bank focused on nanotechnology, also provides access to OPI for companies in this space. They put several conferences throughout the year ranging from health to energy.

New Atlantic Ventures (NAV)

Made early investments in companies targeting high growth emerging mass markets. Its portfolio includes: Nantero, proprietary technology to create logic circuits on computer chips based on carbon nanotubes to "Flash" memory.

Annexe 5 : United Kingdom

Appendice 1 : Authorities involved in Nanotechnologies in the UK

Several structures have been established in the UK in the field of nanotechnology :

The **Council for Science and Technology** (**CST**) is the highest advisory committee of the British government for Scientific and Technological Policy. Its mission is to advise the Prime Minister and the First Ministers of Wales and Scotland on interdepartmental scientific and technological issues. CST organizes its activities around five broad themes (research, science and society, education, science and technology innovation and government) as part of a medium to long term approach. It is composed of senior representatives of the British scientific and technological world (often members of learned societies, including the Royal Society and the Royal Academy of Engineering) and is currently under the joint chairmanship of the Scientific Adviser to the Prime Minister, Sir David King, and Professor Janet Finch. To assess the government's actions on nanoscience and nanotechnology, CST set up a subgroup composed of five of its members, a representative of the Royal Society, a representative of the Royal Academy of Engineering and a co-opted professor of sociology by the subgroup[138].

The government's strategy on nanotechnologies is determined by the **Ministerial Group on Nanotechnologies**, established in 2007 and including representatives from Defra, the Ministries of Health (DH), and Employment and Pensions (DWP).

The **Nanotechnology Research Co-ordination Group** (**NRC**) was established to coordinate public funding research in the area of the potential risks of products and applications of nanotechnology. It is also responsible to establish links in Europe and abroad to promote dialogue and facilitate information exchanges.

Defra chairs the NRCG. Its members include ministries, regulatory agencies and research councils.

Nanotechnology Issues Dialogue Group (**NIDG**), chaired by the Office of Science and Innovation (OSI), is open to the participation of all ministries and agencies involved in the British government's program for nanotechnology. It meets four times a year to:

- Coordinating government activities undertaken in response to the report of the Royal Society and the Royal Academy of Engineering.

[138] René David; *Nanosciences et nanotechnologies : bilan d'étape des actions du gouvernement britannique*, , French Embassy to UK, Service of Science and Technology, April 2007.

- Provide a platform for monitoring progress and commitments made by the government and to inform the CST.
- Ensure that the NRCG work fits into the rest of the government's work program.

Nanotechnology Industries Association (**NIA**) brings together a network of companies active in nanotechnology. The association was created in 2005 to promote the responsible use of nanotechnology and to raise awareness in their potential and their possible applications. The NIA is coordinating the drafting of press releases and documents outlining its positions in areas relevant to its members.

Nanotechnology Engagement Group (**NEG**) was established to stimulate new ways of thinking and methods implemented to involve the general public in nanotechnology. It is based on existing projects to enact recommendations for future research and practice in this area. The NEG is funded by the OSI as part of its program Sciencewise.

TSB is responsible for the promotion, support and investment in technological research, development and commercialization, and provides a translation mechanism of basic research into new products and services. One way for the TSB to promote innovation in this area is the Nanotechnology Knowledge Transfer Network (**nanoKTN, Nanotechnology Knowledge Transfer Network**), between industry and academia.

Appendice 2 : Investisor List

Aldermore

Suppliers of specialized lending services to small and medium-sized enterprises in the UK. He recently provided £ 1.2m installation finances PDA International, one of the areas of interest is a new material that he developed with an expert in tissue York through nanotechnology

Amadeus Cambridge Office Mount Pleasant House, 2 Mount Pleasant, Cambridge

Amadeus Capital Partners Limited has over £ 470m under management. This company has active investments in around 40 companies at any time, across Europe and selectively in Israel - Invested in Plastic Logic, DocumentPower, Power ID

Carbon Trust Investments Limited

Venture capital investments and seed stage to accelerate the commercialization of clean energy companies in the UK - Since 2001, they have invested in 25 companies in the UK cleantech, which raised nearly £ 160 million in venture capital, many in the field of fuel cells and innovation that could benefit from nanotechnology.

Catapult Venture Managers

Specializes in providing Equity Capital between £ 200k and £ 2M, have invested in over 50 companies - Portfolio includes Pharmaceuticals critical (£ 939,000), the Promethean particles (undisclosed amount), Diagnostics Ltd Michelson (£ 676,000), Nanotherics (£ 600,000)

Energy Ventures

Independent venture capital dedicated to the upside in the oil field and new gas technologies - Portfolio includes: Oxane Materials Incfabrique ceramic nano-structured PWA with nano-glass propriétairesréactive

First Capital Corporation Ltd Elsinore House, 77 Fulham Palace Road, London

First Capital is a European investment bank specializing in assisting companies to technology so that they run successfully in strategic transactions - Oxonica managed to raise £ 4.2mn in a Series A financing round. The union includes a strategic investor, US fund of venture capital and several British funds.

IP Group plc 24 Cornhill, London

The IP Group's business heart is creating value for its shareholders and partners through the commercialization of intellectual property - in partnership with a number of academic institutions in the UK - Corporate Portfolio includes: Chamelic, Ilika, Oxford Nanopore technologies, Oxford Advanced Surfaces, Nanotecture Group Plc, Surrey nanosystems Ltd, Stratophase.

London Business Angels (LBA)

Experienced investors who finance innovative enterprises and fast growing - portfolio includes a £ 250k in the first round in the Electrospinning Company Diagnostics Ltd Michelson developer and tomography manufacturer optical coherence (OCT) has raised approximately £ 750k, La company Bac2 own materials and fuel cell components has risen about £ 3 million.

MTI Partners

MTI focuses on start-up companies, particularly those associated with universities. Headquartered in the UK with a US office in Boston investment includes global companies in the materials technology, ITEC and medical technology - Portfolio includes the production of graphene, graphene composites, Fluorographene ....

Octopus Ventures

GPs who tend to focuse on exceptional entrepreneurs teams rather than specific sectors. Looking for capital efficient companies that can grow explosively create, transform or dominate an industry. Focused on the UK and can invest from £ 250k to £ 5 million, with £ 100 million to invest in the next three years- Portfolio includes, Surrey Nanosystems (£ 1.75m), Michelson Diagnostics (£ 1.58 m).

Pond Ventures

Based in Silicon Valley, London and Israel is dedicated to building technology in the worldwide success Storie - Nanotech Semiconductor portfolio includes a British fabless chip company that was recently acquired by Gennum Corporation in April 2011.

QIB

QIP (UK) is the UK subsidiary of Qatar Islamic Bank. He invested in NanoSolutions IOTA which develops nano formulation technologies

Seraphim

Venture capital fund that invests between £ 0.5 million and £ 2 million in high growth early stage UK companies - Portfolio includes: Pyreos with their sensors based on technology "thin" Sirigen and technology based on a new form of conductive polymers

The World Gold Council

Invested in startups with nano technology in the field of gold. Two investments to date; Nanostellar (Diesel Oxidation Catalyst) and Oxford PV (potential use of gold nanomaterials in photovoltaics).

Top Technology Ventures

Top Technology Ventures - UK venture capital firm specializing in equity financing for young technology companies based on growth stage. Focuses on high-growth technology companies, with the first investment is generally between £ 400,000 and £ 1.0 million. In June 2004 Technology Ventures is part of the Top IPGroup plc. Portfolio includes: Nanotecture Limited, Oxford Nanopore Technologies - Developing nanopore technology, a revolutionary method of molecular detection and analysis with potential applications in DNA sequencing, diagnostics, drug development and defense. Oxford Catalysts - specialty Catalysts for the generation of clean fuels, fossil fuels From Both conventional and renewable sources Such As biomass.

Ventures Albion

This company had invested between £ 1 million to £ 10 million in a wide range of growing businesses, companies in technology-oriented service companies. Its portfolio includes: MEMStar Oxonica, Oxensis, Perpetuum, Teraview ...

Unilever Ventures 1st Floor, 16 Charles II Street, London

Unilever Ventures (UV) is the European venture capital arm of Unilever. We invest in start-ups that could become strategic for Unilever and can benefit from access to Unilever's assets and capabilities. UV concentrates its investments in: health and vitality. Personal care, digital marketing, new foods. UV invested in IOTA NanoSolutions which develops nano formulation technologies.

Wellcome Trust Wellcome Trust, Gibbs Buildingn, 215 Euston Road, London

This fund bridges the gap between basic research and commercial application by funding applied research and development projects to a stage where they are attractive to a lender. essential criterion is that the project meets a medical need or vacant is a tool for research and development of health care. It also offer a variety of other funding schemes.

Annexe 6 : Russia

Appendice 1 : The Research in Russia

1. Presentation

The organization of research in the USSR was marked by a separation between R&D and production, research being conducted in separate structures of production units: institutes and consulting firms. Research centers can be attached to the military industrial complex, or to an Academy of Sciences, or finally to a ministry branch partitioned each other. Production plants had no real R&D internal structures, except for some offices and control procedures.

Since 1992, the Academy of Sciences of the USSR was replaced by the Russian Academy of Sciences. Despite the name change, it has successfully negotiated its autonomy and to maintain its control over the distribution of funding to the institutes that were attached to it, but its budget was drastically decreased.

The previous institutes have been transformed into public or private research laboratories, or to engineering, consulting and high technology companies. From 1992 to 1995 there has been an evolution of some institutes of the Academy of Sciences to industrial laboratories, a transformation of institutes into enterprises or branch disappearance, swarming P.M.E. hightech, created by researchers[139].

In November 1994, the state again reduced the scope of its active support in creating the Federal Research Centres, status awarded to the best institutes of the Academy of Sciences. However, only a small fraction of all the institutes of the Academy of Sciences enjoys this privileged status. These scientific centers of state also saved former military institutes (twenty sites were affected). Banned from privatization, the RAS institutes had only alternative to transform themselves into public industrial laboratories

[139] When institutes, lack of funding, have been forced to abandon research, many have offered researchers to continue their own projects alone. This solution, at first, mutually convenient: Researchers ensuring the maintenance of the Institute equipment they needed, hoping to sell for their own account the results of their own research. Many had indeed received under the socialism some certificates, nominally assigning authorship of inventions. These certificates have since been transformed into industrial patents, researchers found themselves owners of the technology they had developed, which strongly encouraged to develop their own applications when they no longer paid by the Institute. This solution to the temporary origin finally gave birth to a myriad of P.M.E. early 1992, more than 300 private companies from institutes were already registered in Russia.

Moreover, Russia has established structures to organize financing in the mode of the call for proposals: the *Russian Foundation for Basic Research* was created in 1992 and the Russian *Foundation for the Humanities* in 1994.

Other foundations were created to support R&D and innovation:

- for applied research, the *Fund for Assistance to Small and Medium Enterprises* (FASME) provides an opportunity for researchers to start or continue their development in the context of a start-up or SME created even within of their own institute.

- for fundamental research, the *Russian Foundation for Basic Research* (RFBR) provides funding for research on selected tenders in order to maintain a good level of research. Nanotechnology is perceived approximately € 7 million in 2005. It is an independent state agency created in 1992 under the control of the Ministry of Education and Science (MES).

Scientific research has therefore not, at the beginning of the transition period, been seen as a potential lever for economic restructuring of the country.

2. The structure of the current research

Russia today is characterized by a huge potential in human resources, but at the same time by important weaknesses [140].

The majority of the entities in the Russian research consists of structures for most inherited from the Soviet era. They numbered 3600 in 2004, which can be classified into several groups :

- **Research institutes of the Russian Academy of Sciences (RAS)**: the Russian Academy of Sciences plays a major role because it contributes both to the development of science policy, in coordination with the Ministry of Education and Science, and the implementation of this policy, through the guardianship of a network of research institutions (nearly 450 institutes in 2005 and over 100 000 people). The expenses of the ASR totaled in 2005 to € 750 million (representing nearly half the federal budget for basic research).

- **Institutes of applied research** historically associated to sectoral areas of industrial activities, which constitute about half the total number of research institutes in Russia.

[140] A significant portion of the Russian population went up higher education. With over 50% of the younger generation (25-34 years) in reaching higher education, Russia has the most graduates in OECD countries sciences. Despite the workforce downsizing, Russia can count on a team of R&D excellence especially in the sciences, inherited from the Soviet Union.

- **State Research Centers** (SRC), from most structures of the military industrial complex, numbering about sixty. SRC label is awarded by government decree to institutions conducting research with strong applied component.

- The **Universities**. In fact only the most prestigious develop research activities, the others being mainly oriented education,

- The **Private centers of R&D**, dependent mostly large companies (about a thousand).

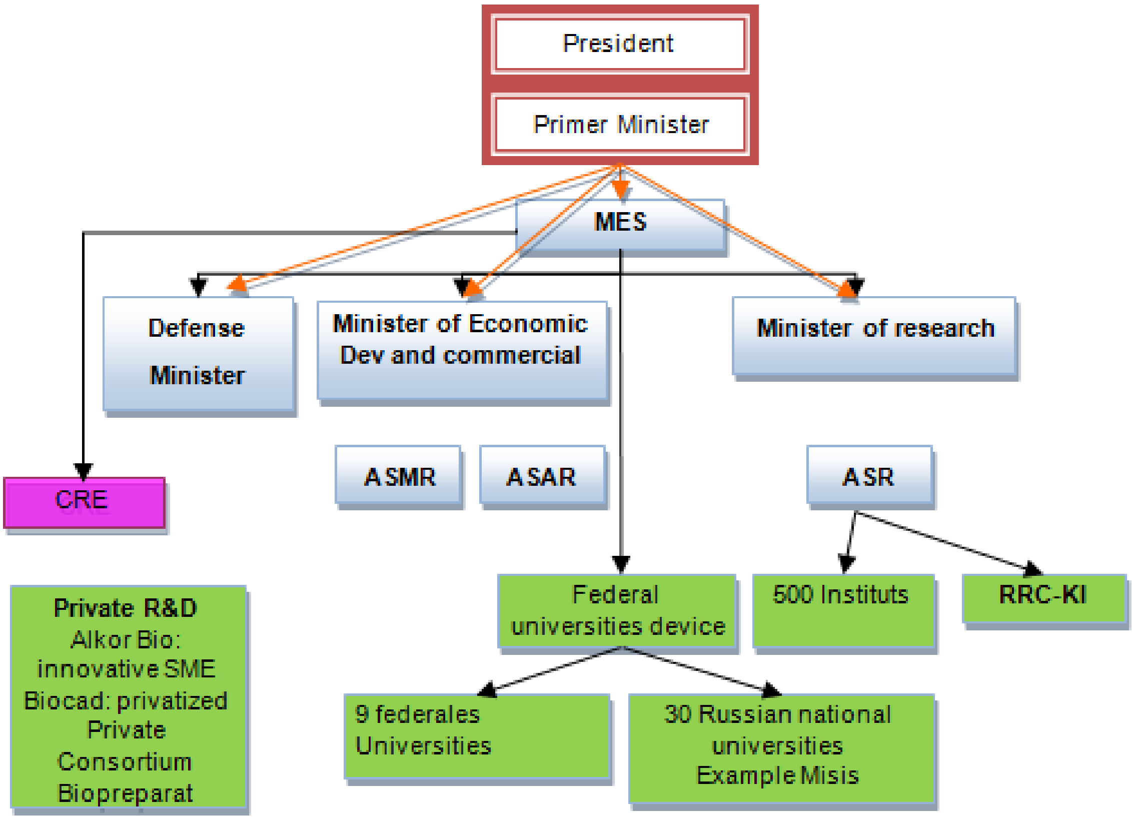

Figure 79. Stakeholders of Research and Development in Russia.

Piloting and research funding at the federal level

Unlike developed countries, where industrial companies contribute more to research than the state, Russian companies have not yet started to invest heavily in research. Indeed, the share of industrial enterprises in the total amount of expenditure for R&D is only 22.8% in 2003[141].

[141]Irina Dezhina « *Où sont ? Où vont les scientifiques russes ? Ressources humaines et politique de la recherche en Russie* », Ifri, Paris, June 2005.

The Government continue to fund 60% of R&D in Russia. Foreign financing is 7.5%.

Due to these economic improvements and policy prescriptions, there was more funding in the R&D sector. According to official statistics, the total expenditure for R&D amounted in 2005 to about € 6.6 billion, representing 1.07% of GDP. The structure of total expenditures gives a central place to targeted research and development (70%),[142] while only 15% of spending goes to basic research.

L'élaboration de la politique scientifique est le résultat d'un consensus entre différents organes politiques. Le ministère de l'Education et des Sciences (MES) y joue le premier rôle : il coordonne et intègre les propositions et les plans des autres ministères, agences et Académies des Sciences pour la politique scientifique et technologique. Il dresse une liste des priorités nationales. Toutefois depuis la création du Conseil pour la Science et la Technologie auprès du président en 2002, la Présidence a une influence directe sur la politique scientifique.

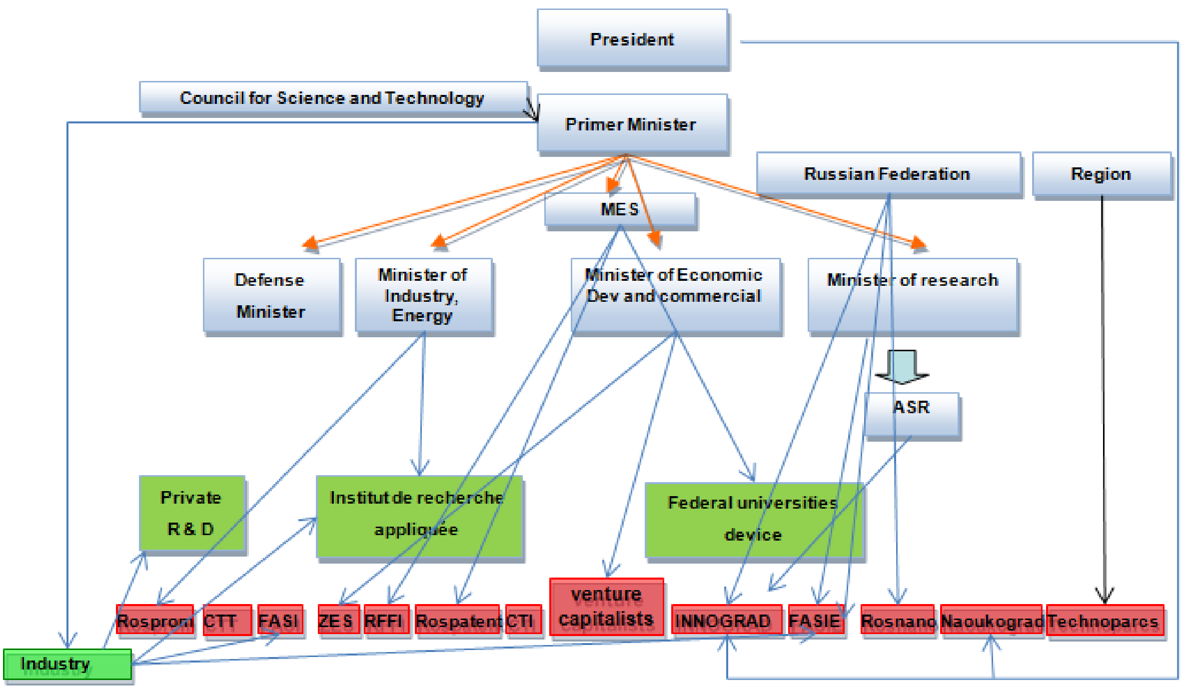

Figure 80. Management of the organizations involved in innovation in Russia.

Technology Transfer Centers: there are 48 TTC, with funding from the ministry, they have a regional vocation.

Special Economic Zones (SEZ): like the French competitiveness clusters, should foster incubation between research and technology application. They benefit from significant taxes exemptions.

Technological Innovation Centers: There are 61 TIC, regionally oriented, self-funded, playing a role as an incubator of high technological value projects.

[142] Because of the predominance of military activities.

Head of State: Since 1991, the President is the key stakeholder in the Russian political system. In particular it can dissolve the Duma.

Head of Government: Prime Minister. Executive power is exercised by the head of government. The legislative power is vested in both the government and the two chambers of the Federal Assembly of the Russian Federation.

Lower House: The Duma, has a leading role in the development of legislation. Upper House: Council of the Federation, much lower than the Duma.

Russia's venture capital: created in 2006 to deal with weak private venture capital. It had received from the Ministry of Economic Development a federal allocation of € 420 million and continues to act as a fund of funds.

Council for Science and Technology : Created in 2002 to the President of Russia. The Presidency thus has a direct influence on science policy.

FASI : Federal Agency for Science and Innovation. It manages several federal programs relevant targeted Russia for R&D.

Russian Federation: develop innovative SMEs thanks to income from fossil resources.

INNOGRAD at Skolkovo (Moscow): Research center for development and commercialization of new technologies (energy, information technologies, telecommunications, biomedical, nuclear). Created by the Academy of Sciences, State Corporation *Bank for Development and Foreign Economic Affairs* (Vnesheconombank), Rosnanotec, Bauman Moscow State Technical University, Russian Venture Company and the FASME

Institutes of applied research: 3566 organizations identified in 2005.

Ministry of Education and Science (MES): established in March 2004, co-ordinate and integrate the proposals and plans of other ministries, agencies and academies of sciences for science and technology policy.

Naukograd: Physical infrastructure: scientific cities, technoparks, transfer centers and special economic zones.

Rosnauka : Federal Agency for Science and Innovation. It funds research applied call for projects each year: development of scientific knowledge, technology development, technology commercialization. With a budget of more de1,15 billion in 2006, RosNauka has funded 2700 projects, including 134 international dimension in cooperation with 25 countries. Rosnauka Under his tutelage the Russian Fund for Technological Development

Rosprom : Rosprom, born in February 2004 by decree of President Putin, is formed from the merger of several agencies responsible for armament and Rosavaikosmos Space Agency. Rosprom must finance technologically innovative industrial projects for 156 million euros between 2007 and 2012.

Technoparks: created in the late 1980s, they are the first element of a policy of infrastructure creation to foster innovation and technology transfer. They consist of a set of SMEs.

Current policy orientation

Political power took control in 2001 on the foundations requiring them to declare themselves "governmental organizations" and by assuming ownership rights to the technologies developed.

In addition, since 2000, things have accelerated and the government has given high priority to defense and military research by an incentive policy: there was creation of scientific studies, higher wages proposal for researchers and teachers, etc.

3. Conclusion

Aware of the difficulties of Russia to maintain its place in the competitive context of research and high technologies worldwide, the authorities **since the early 2000s (in continuity with the first efforts initiated towards 1990) undertook a series of reforms background for boosting basic research and establish a system of innovation and technology transfer** that is both effective and has engaged on the economic realities of the country. This policy includes a multitude of areas: legal, tax, regulatory, legislative, financial, help and support from the state, etc.

Appendice 2 : Institutes of excellence in nanotechnology

1. Ioffe Physical-Technical Institute, Russian Academy of Sciences (RAS), Saint Petersburg

Description

Despite its large size, the activities of this institute are always at the forefront of science and he managed to turn his technology with many applications in electronics, nano-electronic, opto-electronic, spintronics, imaging, sensors, etc. It is also a breeding ground for creation of innovative SMEs.

Specialized topics

Heterostructures, especially in the III-V systems (Nitrides of Ga, Al, In), thin film growth by epitaxy, optoelectronics, crystalline and amorphous semiconductors, dielectrics, electronics and nano-electronics, spectroscopy...

2. Chernogolovka Institute of Solid State Physics (RAS), Moscow Region

Description

Founded in the early 60s, the institute is still one of the top performers in its field, especially at the basic level. An application and development sector is developing dynamically, especially in the field of materials.

This institute has many links with the outside world, especially with the Landau Institute theorists. Internationally, it has numerous collaborations, particularly with several French laboratories for many years (Paris, Orsay and Grenoble).

Specialized topics

Superconductivity, quantum transport, giant magnetic susceptibilities.

Crystal growth of technological crystals, nanostructured materials, nanotubes, quasicrystals, quantum crystals, semiconductors, ceramics, composites, refractories, etc...

Surfaces, interfaces, physical defects, phase transformations.

Optical, electrical, magnetic, mechanical properties.Spectroscopy and microscopy.

3. Institute of Semiconductor Physics (RAS), Novosibirsk

Description

Founded in 1964, the institute is the best in the field of semiconductors, both in terms of basic research and applications.

Specialized topics

Growth and structure of semiconductor materials, micro-photoelectron, physics and technology of semiconductor low-dimensional (micro and nanostructures), quantum electronics, structures of thin films for microelectronics and photoelectron, physical and engineering of semiconductor structures, R&D development of monocrystalline silicon and silicon structures. Atomic force microscopy, nanolithography, LIGA.

4. Institute of Microstructure Physics (RAS), Nizhny Novgorod

Description

Although founded only in 1993, IMP is a major nanotechnology centres of excellence through fundamental research in physics of surfaces and interfaces, semiconductors, high temperature superconductivity, optics X-rays. His instrumental park, well managed by a dynamic team (not bloated), allows it to attract good young researchers from the neighbouring University.

Specialized topics

Physics and technology of metal structures, semiconductors, superconductivity, heterostructures and nano-systems.

Embodiments of semiconductor sources for terahertz generation frequency and the components for optoelectronics (photo-luminescence, light emitting diodes).

Scanning microscopy, atomic force tunneling, SNOM, High Resolution Spectroscopy, MOCVD, MBE, laser ablation, RIE, many systems characterization and tests (X-ray, AES, SIMS, SEM), Cleanroom Class 1000 and 100.

5. Prokhorov General Physics Institute (RAS), Moscow

Description

Created in 1983 by Academician A.M. Prokhorov (Nobel Prize in 1964 and inventor of lasers) from the "A" division (plasma physics laboratories) of the Lebedev Institute (created it in 1934).

Specialized topics

In FORC: Raman fiber lasers and doped, electrostriction effect, photoréfaction effect in doped fibers, losses mechanisms in fibers doped with germanium and phosphorus, sensors, fiber to the nuclear industry, research new doping, non-linear crystals, fibers covered with a metal surface (copper, nickel, etc.). Very good collaboration with French teams (on fiber lasers with Limoges, nanotubes with ONERA-CNRS, metal surfaces with Nancy).

Nanotechnology: Production and characterization of carbon nanotubes by various methods, and then processing into film having simple and many applications, heterostructures, developed on a nanostructured noble metal substrates by reaction with a halogen gas.

6. NikolaevInstitute of Inorganic Chemistry (ASR), Novosibirsk

Description

Created in 1957, this laboratory is one of the first institutions of the new Siberian Branch of the Russian Academy of Sciences.

Specialized topics

Synthesis (and characterization) of the crystals of all kinds: BGO crystals (10 to 20 Kg) single crystals doped with rare earths.

Nanostructured transparent ceramics, colored, transparent to IR, systems Si (or B) NxCx: H variable composition. Preparation of metals (particularly rare earth) by reduction of the corresponding oxide with lithium hydride (LiH).lanthanide borides synthesis (LnB6) almost as hard as diamond. Super magnets realizable by powder metallurgy.

Polymer chains for micro and nano-materials for storage and transportation of gaseous hydrocarbons.

Low temperature synthesis of nanocrystalline CdS films, Cdx Zn1-x Cu 2 S and PbS using dithiocarbonates as single source precursors.

Synthesis by arc discharge andCVD of the carbon nanotubes, possibility of doping, electron structure (metal or semiconductor), chemistry, properties. Optimization of carbon nanotubes is sought to achieve nano-X-ray sources and the study of the magnetic properties of Co-Fe aggregates (collaboration with École Polytechnique: Alexandre Sharaya, Hubert Pascard and Olivier Klein). Superconductivity.

7. ShubnikovInstitute of Crystallography (RAS)

Description

The Institute was founded in 1943 by the eminent physicist Aleksey V. Shubnikov (1887-1970) under the auspices of the USSR Academy of Sciences.

This great Institute, dedicated to the Crystallography, is unique. On the multidisciplinary nature, it is born of geological and mineralogical studies by integrating the chemical aspects, then evolved towards more fundamental investigations of the crystal (structure, properties, etc...), with the powerful methods of physics, especially X-ray. It also developed many synthetic crystal growth processes of different kinds and sizes giving it the status of a national provider of quality crystals, not only in Russia but also in the global market (Investment 2005: $ 40 million).

Today, thanks to its multidisciplinary tradition, the Institute has quickly turned to modern subjects: growing special crystals off gravity (in orbit), LCD (optoelectronic devices), growth of piezoelectric crystals (mobile phones) or biological and especially nanotechnology. In this area, the Institute plays a leading role and national coordinator: It was named "national contact point" for the participation of Russian teams in the programs of the 6th European Framework Programme.

Specialized topics

Crystal growth and associated technologies (characterization by X-rays, for Synchrotron Radiation, spectroscopy, microscopy, mechanical, optical, electrical, etc ..), thin film, nano centers of manufacturing, organic crystals, membranes, nano-biotechnology, ultrafiltration, liquid crystal, crystal technology (ferroelectric, piezoelectric, magnetic, semiconductor, quartz, sapphire, oxides, etc...)

8. Institute of Structural Macrokinetics (ISMAN) (ASR), Chernogolovka

Description

Founded in the 70s on the basis of a discovery of his Director, Academician Alexander Merzhanov, this institute founder of a new branch of chemistry of materials, specializes in the synthesis of new materials by reactions "SHS" (Self Propagated High Temperature reactions).

Specialized topics

Synthetic materials (where most of the elements of the Mendeleev classification were used successfully), protective coatings, anti-corrosion, ultra-hard materials, thermal shock resistant, abrasive powders, filtration materials, etc.). Manufacture of ceramic SHS by high pressure gas, developing new alloys mechanically activated SHS, formationof nano-layer and multilayer by the SHS process.

9. Boreskov Chemistry Institute of Catalysis (ASR), Novosibirsk

Description

Created in 1958, this is the largest institute of chemistry is Russia. Living largely from revenues it collects from foreign companies exploiting their patents, the institute has means for moving from laboratory scale to industrial scale pilot (performance equipment: XPS, ESCA ...). About a third of its budget comes from contracts, especially with Chinese and South Korean companies.

Specialized topics

Manufacture of photocatalytic TiO_2 (modified Pt powders), fibrous carbon (nanofibers and nanotubes at 2.5 kg / day), SiC nano-fibers coated with amorphous carbon, nano-diamond for polishing, carbon (graphite) for porous filtration, meso-porous materials based on silica, aerogels SiO_2-NiO, etc. Specializing in carbon nanotubes (CNTs), dediamètre nanometer (5 nm), researchers have numerous collaborations ("onion-like carbon").

They also study the manufacturing methods of nano tips for scanning tunneling microscopes.

Development of new catalysts (Fe-Mn for the synthesis of SiC whiskers...).

10. Chemistry Institute of Solid and Mechanical Chemistry (ASR), Novosibirsk

Description

Created in 1944 (as "Chemical Metallurgical Institute"). The Institute is organized into three main areas of investigations, affecting the chemistry of the solid state, the design of new materials, mechanical and chemical activation chemistry, electro-chemistry, new materials and bases new technologies.

Specialized topics

Very interesting fundamental work to understand the phenomena occurring during the synthesis reactions by mechanical-chemistry of nanostructured oxides such Al203 and ZrO_2. Study of the influence of mechanical activation on agglomeration of ceramic oxide powders in nanometric grains: 20-25 nm (less than 0.5% Fe) and 40-45 nm (less than 0.02% Fe).

Fundamental study of SHS process with investigations on the neighbouring Synchrotron, to access measures diffractometric fast enough to follow the kinetics of reactions. SHS process, coupled with mechanical activation (high energy milling) is used for synthesizing nanopowders at low cost.

Sintering of nanopowders leading to well densified ceramic in which the nano-structuring is preserved by SPS technology (Spark Plasma Sintering) with Korean.

Development of nanostructured deposits TiB2 / Cu electrical discharge (electric arc) for electrode.

Fluent deposition of protective coatings (Al203, ZrO2) on nano-grains of C or SiC.

Institute turned to the Far East (Japan, Korea, China) for lack of collaborations with Western laboratories.

11. Laser Physics Institute (ASR), Novosibirsk

Description

Founded in 1991, the Institute remains one of the best in the field of basic research in lasers and has recently developed a number of applications, particularly in medicine.

Specialized topics

High resolution spectroscopy, frequency stabilization (He-Ne/CHn), femtosecond optical clock system and frequency synthesizer, cooling of atoms, etc.

On the sidelines with these fundamental studies, the Institute develops many elements of optical frequency standards, femtosecond synthesizers, lasers for medicine, biology and ecology, tunable single-frequency lasers, optical clocks femtosecond fluorescence spectrometers, laser instruments to measure small displacements, excimer lasers, etc.

This Institute is being relocation to Moscow and St. Petersburg, the future direction of his research are not clearly visible despite strong ties with the University of Paris-Nord Villetaneuse (it is part of a Franco-Russian GDRE) and other strong international partnerships, mainly with Germany, Britain, Japan and Korea.

12. Institute of Strength Physics and Materials Science (ASR), Tomsk

Description

Founded in 1991, the Institute is probably the best in the field of mechanics of materials, both in basic research and for numerous applications in the synthesis of new materials with high mechanical and functional characteristics. Very active, with close collaborations with other Tomsk centers, ISMAN of Chernogolovka and Solid State Chemistry Institute of Novosibirsk, the Institute attracts many quality young researchers.

Specialized topics

Fundamental work on nanomaterials: thermodynamic and mechanical calculations on the grain boundaries in nanomaterials compared with the same materials but with micrometric grains. Experimentation and modeling.

Development of nanostructured bulk materials by PSD (Severe Plastic Deformation). Titanium Application: pure titanium obtained by PSD can be used, instead of its alloys for prostheses (no toxic alloying elements).

Nanostructured materials: surface treatment, production of superhard coatings (Ni3Al) for cutting tools and machine parts (microhardness of 35-55 GPa).

Surface treatments on the treads of railway wheels, inner linings of molds.

Superhard nanostructured coatings: Altio, ZrTiNC, AlTiON, AlTiNC, TiN, TiC, TiCN, TiBCN; up to 20 Pa. électroplasma coating solution including light metals (IT, Al) for reinforcement and protection (Y2O3 Al seems possible).

Synthesismethod of oxide nanopowders by plasma (ZrO2-Y2O3-Al2O3 9 nm, ZrO2, 3% Y2O3 20 nm) of alumina nano-fibers (applications for ultra-filtration).

Preparation of nano-ceramics (ZrO2 / Al2O3 composite) with a controlled porosity between 10% and 70%.

Preparation of highly dense ceramic for cutting tools.

13. Other centers of interest with activities in Nanotechnology and Materials

Moscow: Lomonosov University, MISIS University, Mendeleyev University, MIPHY University, General Physics Institute (RAS) and the Fiber Optics Research Center (FORC)

Region of Moscow: Zelenograd: NT-MDT Company ; Chernogolovka: Institute of Problems of Physical Chemistry and the Institute of Microelectronics Technology and High Purity Materials ; Troitsk: Physics Institute of High Pressure, spectroscopy Institute

St. Petersburg: State University of Technology: Inorganic materials, ceramics and glass, hybrid metal/ceramic, fibrous single crystals. Centre Svetlana-Optoelectronics: electroluminescent diodes

Ekaterinburg: Institute of Metals and Institute of Electrophysics

Nizhny Novgorod: University "Lobachevsky": semiconductor nanostructures, epitaxy of GeSI islands on single crystal silicon, nano-Si crystals embedded in a matrix of amorphous silica on silicon (luminescence).

Appendice 3: Valuation of Russian Research by Rosnanotech

Until recently, Rosnanotech (Russian Corporation of Nanotechnology: CENT or Russnanotekh, July 2007) communicated little about its activities. It was during the International Economic Forum in Saint Petersburg in June 2011, Anatoly Chubais, Chief Executive General and executive board chairman, spoke to bring more information:

It is a company that invests in innovative nanotechnology, it also helps companies when marketing.

Rosnanotech projects by category:

- Nanomaterials: 44%
- Technology of efficient energy: 15%
- Pharmaceutical products: 17%
- Nano-coatings: 10%
- Optical and electronic: 10%
- Other: 4%

Rosnanotech has an important role in various stages of R & D. Particularly in the private sector, Russian or foreign, if part of the production is done in Russian. It is also involved in the public domain through the training of specialists, partnerships with private investors, the financing of innovative projects that may lead to startups. As venture capital, it promotes the transfer of technology. In the industrialization phase, it can finance infrastructure, certification and risk assessment, but it rarely provides more than half the share of investment. It accepts an average of 1 file out of 20 candidates.

Some numbers:

- Applications for funding: 1,967
- Applications approved: 113
- Total budget: 381.6 billion rubles
- Number of applications submitted by the companies: 30
- Number of regions involved in the project Rosnanotech: 30

[NIKITA DULNEV, Rosnanotech's big nanotechnology secrets revealed, *Russian Beyond the headlines,* 3 August 2011]

Rosnanotech was founded in March 2011 as a corporation, opened by the reorganization of state corporation Russian Corporation of Nanotechnologies. The Government of the Russian Federation owns 100 percent of shares of Rosnanotech. Anatoly Chubais is the executive director of Rosnanotech.

[Rosnanotech *and NEARMEDIC PLUS to Create New Nanomedicine Production Facility*, Rosnanotech, 17 octobre 2011]

		Unit	2008	2009	2010	2011	2012	2013	2014	2015
1.	The Corporation financing of the projects on nanoindustry products manufacturing development, establishment of nanoproducts markets (investment projects)	billion rub	8	10	12	12	12	12	12	14
2.	The Corporation financing of the infrastructure projects and programs in the field of nanotechnology and nanoindustry, scientific foresighting and roadmaps development, information activity, works on standardization, certification and metrological provision, nanoindustry security provision	billion rub	3	3,5	5	3,5	2	2	2	2
3.	The Corporation financing of the projects in the sphere of education, science popularization, promotion of Russia's public image as one of the world nanoindustry centers	billion rub	3	2,5	2	1,5	1,5	1,5	1,5	1,5
4.	Investments attracted in the Corporation projects at the expense of non-budget sources	billion rub	0,5	3	6	9	11	12	14,5	18
5.	Besides, investments at the expense of the Corporation activity profits	billion rub	6	5	4	3	3	4	5	6
6.	Investments — total (sum of lines 1 to 5)	billion rub	20,5	24	29	29	29,5	31,5	35	41,5
7.	Sales volume of Russian nanoindustry products/ including as the result of the projects implementation with participation of the Corporation	billion rub	20	80	155	240	340 / 10	470 / 50	650 / 100	900 / 300
8.	Specific weight of the domestic nanoindustry products in the overall volume of nanoindustry products, realized on the world high-tech market / including as the result of the projects implementation with participation of the Corporation	%	0,07	0,25	0,45	0,80	1,35 / 0,04	1,85 / 0,2	2,4 / 0,38	3,0 / 1,0
9.	Volume of nanoindustry products export / including as the result of the projects implementation with participation of the Corporation	billion rub	4	11	19	31	52 / 2	81 / 10	124 / 20	180 / 60

"Russian Corporation of Nanotechnologies" activity until the year 2015

[*Business strategy of State Corporation "Russian Corporation of Nanotechnologies" until the year 2020*, Rosnanotech, mai 2008]

Team : Leonid Melamed 1° General Director, M. Anatoly Tchoubais[143] (sept 2008) 2°DG

M. Malyshev Deputy Director

M. Mostinsky/S. Motsinskiy International relations Director

Rosnanotechannounces the incorporation of investment management companyRosnanotechCapital AG, June 30, 2010

Rosnanotechannounces the completion of the incorporation and registration procedure for the investment management company RosnanotechCapital AG. RosnanotechCapital AG will be involved in attracting global investors for financing promising Russian innovative projects as well as investing in existing international technologies with the aim of implementing them in Russia.

[143] First Deputy Prime Minister (1992-1996 and 1997-1998) built the privatization program. Appointed in 1998 to head Rao United System (ues), public monopoly producing 70% of Russia's electricity, he led the reform of the electricity sector, officially ended with the disappearance of Rao ues on 1 July 2008. Currently responsible development of nano-industries in Russia.

RosnanotechCapital AG is registered in Switzerland and will monitor and maintain control over the establishment and activities of funds invested in specialized innovative technologies. Andreas Kazutt, a partner in the law firm “Niederer Kraft & Frey”, has been appointed as the Local Director of RosnanotechCapital AG in Zurich.

Rosnanotechis the exclusive shareholder of RosnanotechCapital AG and for the purpose of conducting consulting activities in Russia a subsidiary company called RosnanotechCapital LLC has been incorporated. RosnanotechCapital LLC is headed by Irina Rapoport.

“Our intention is to render integral support to our partners as per issues concerning gaining access to investments in Russian research activities and challenging projects,” - Irina Rapoport said. “We are already aware of global players’ interest in different research and development activities, including such areas as: alternative power-engineering, innovative materials, biotechnologies and pharmacology. We trust that we’ll be able to considerably increase the volume of foreign investments in leading Russian research and development activities as well as make our contribution to world innovative technologies transfer to Russia.”

Source: Rosnanotech (press release)

RosnanotechSigns Investment Agreement for the SynBio Innovative Pharmaceuticals Project, 5 août 2011.

Rosnanotech, the Human Stem Cells Institute, Pharmsynthez, Cryonix, FDS Pharma LLP (United Kingdom), and private investor Dmitry Genkin have signed an investment agreement for the SynBio project. The project’s purpose is to develop innovative medicines and biobetter pharmaceuticals. Lipoxen PLC, a British pharmaceuticals developer for leaders in the global pharmaceuticals industry, and German company SymbioTec GmbH will be the principal R&D partners for the project.

The partners have established limited liability company SynBio to carry out the project, which has a total budget of 3.2 billionrubles. Of that sum, Rosnanotechwill co-invest up to 1.3 billion rubles. The other founders will co-invest up to 1.9 billion rubles in the form of monetary resources, intellectual property rights, and shareholding in their own and subsidiary companies. The investment period will be four years, and the project is slated to run seven.

The SynBio project will develop and launch nine pharmaceutical products for Russian and international markets. The medicines are based on three technological platforms:

- stem cell technologies for treatment of chronic diffuse liver disease (the Gemacell platform)
- intranuclear human protein histone H1 for treatment of cancers and other diseases (the Histone platform)
- sustained-release drugs using polysialic acid-biobetters for treatment of diabetes mellitus, Alzheimer’s disease, chronic kidney disease, and other illnesses (the PolyXen® platform).

Biobetters resemble biotech pharmaceuticals that already exist in the market, and they differ in that they surpass the biotech preparations by certain characteristics, such as effectiveness.

All the medicines in the project are currently undergoing pre-clinical tests or clinical trials in research laboratories in Russia and Europe. All the pharmaceuticals developed within the project areexpected to be sold in the Russian and international markets. Sales of SynBio's drugs in 2015 are forecasted at 700 million rubles.

"Two facilities will be established for commercial production of the innovative medicines, one each in Leningrad and Moscow oblasts," explained **Olga Shpichko**, Rosnanotechmanaging director. "Manufacturing will be set up jointly with our German and British partners. We regard this as a step toward entering the international pharmaceuticals market."

Artur Isaev, general director of the Human Stem Cells Institute: "It would be difficult to over-estimate the importance of today's events for us and our partners. This is the first time that a Russian company has initiated a M&A in the biotechnology sector to serve the Russian and global markets. The project intends to introduce a number of innovative drugs that will bring real progress in the treatment of socially significant diseases. Our project is an excellent example of how the government's program for innovative development of the Russian pharmaceutical sector can be implemented."

An R&D center for composite materials will be opened atSkolkovo10/26/2011

As part of the 4th International Nanotechnology Forum, the Skolkovo fund and theComposite Holding Company signed an agreement to organize an R&D center for carbonfiber based polymer composite materials which will be located at Skolkovo. The documentwas signed by **Viktor Vekselberg**, president of the Skolkovo Fund and **Leonid Melamed**,president of the Composite Holding Company in the presence of **Sergei Kirenko** head ofRosatom State Corporation and Rosnanotechchairman of the board **Anatoly Chubais**.

The signed agreement established primary target parameters up to 2015 for the R&Dcomposite materials centerwhich will become part of Skolkovo Innovation Center. The newcenter will employ 25 people, including 2 foreign specialists.

The total investment planned for the R&D center until 2014 will be around 600 millionrubles, including 300 million that Composite Holding Company plans to attract from theSkolkovo fund. The annual budget of the R&Dcenter, will be approximately 200 millionrubles starting from 2015.

The Composite research and development center (hereafter Composite RDC) will conductresearch as part of Skolkovo's nuclear technology program supported by the SkolkovoFund. The primary mission of the R&D center is to conduct research aimed at perfectingcarbon fiber production technologies. This research will be focused on development of newmethods for production of polyacrylonitrile precursors and carbon fibers, and on creation ofnew products made of high-test polymer composite materials. The main goal is tosubstantially raise the quality of Russian-manufactured carbon fiber and provide lowerprices for such material. Carbon fiber is extremely light, durable, and highly weather-lightand penetrating radiation resistant. These fibers are used to reinforce composite, insulation,chemo-resistant and other types of materials and as addition to various carbon plastics.

"In our program of polymer composites usage in the atomic industry products, which makesprojections up to 2020, we have a separate section dedicated to scientific research in thisfield. We are prepared to test solutions which will be brought out by this R&D center at ourproduction facilities, and successful ideas can be applied not only at our own facilities, butalso in other branches of atomic industry." **Sergey Kirienko** said.

Viktor Vekselberg noted: "It is gratifying, that more and more Russian companies areshowing interest in finding practical forms of cooperation with the Skolkovo fund. We arealready supporting creation of research structure at Skolkovo for such Russian companiesas Sberbank, Information Satellite Systems named after academic Reshetnyov, and Rocketand Space Corporation "Energiya". Working with the Composite company will make itpossible to support development of Russian skills and technology in the field of compositepolymer materials, which, in many ways, is significantly less developed in Russia than in theleading countries. Scientific research dedicated to perfecting technologies for the productionof carbon fiber is of extreme importance; after all, this is a unique material, the material ofthe future. Its characteristics have tremendous potential for use in various branches ofindustry, which makes it possible to truly consider it as one of the materials of the 21^{st}century. This R&D center is created in order to significantly raise the quality of Russianmanufacturedcarbon fiber, and reach the level of skill and technological development thatexists in the rest of the world.""Until quite recently, corporate science in the field of polymer composite materials basedon carbon fiber in Russia existed on an isolated basis. Using this composite materials R&Dcenter, we plan to bring pure science, universities and business together. Our goal is toorganize the process in a way that science will solve problems important to business." Said**Leonid Melamed**.

Information. The Skolkovo Fund

The development fund for the Skolkovo center for the development and commercialization of new technologies is a nonprofit organization, created by an initiative of the president of the Russian Federation, Dmitry Medvedev, in September of 2010. The Fund's mission is to mobilize Russia's resources in the field of modern applied research, the creation of an encouraging environment for new developments in five significant fields of science and technology: energy and energy efficiency, space, biomedicine, nuclear and computer technology. This project involves the creation of the Skolkovo institute of Science and Technology (SIST), research institutes, a business-incubator, a center for the exchange oftechnology and commercialization, representative offices of foreign companies and R&D centers, living facilities and social infrastructure, as well as establishing an effective system for the distribution of Russia's investment resources. The activities of the Skolkovo innovation center are regulated by a special law, which guarantees special economic conditions to its residents. www.i-gorod.com

The Composite Holding Company was created in order to form a market for composite materials in Russia in 2009. This vertically integrated holding company includes enterprises involved in producing highly durable and highly modular carbon fibers (JSC Argon, LLC Composite-Volokno, LLC ZUKM), fabrics based on those fibers and high quality prepregs

(CJSC Prepreg-SKM), which are used in the aviation industry, construction, the automotive industry, shipbuilding, etc. Among the Holding’s tasks are the creation of highly efficient, environmentally friendly production of carbon fiber and carbon fiber products on the basis of innovative technologies for the production of continuous and discrete fibers. The CompositeHolding Company plans to occupy a leading position in the engineering, production and sale of next-generation composite materials and satisfy the demands of the aforementioned industries for domestically made next generation composite materials.

The Rosnanotechforum is a place to discuss and demonstrate innovate technology in machine building and metal processing, optical electronics and nano-electronics, solar energy and energy efficiency, medicine and biotechnology, the new branch of industry devoted to producing nano-patterned materials, and infrastructure projects.

The Forum’s mission is to give participants an opportunity to discuss the primary tendencies of global scientific and technical development and key trends in the investment process in the hi-tech sphere, and encourage the practical commercialization of new projects inside Russia:

- present concepts to potential investors and partners,
- select promising investment opportunities,
- find suppliers of innovative products,
- create a network for the completion of projects,
- establish new contacts on various levels.

The international nanotechnology prize, ROSNANOPRIZE, is proudly awarded at the Forum. The Forum program includes an award ceremony for recipients of the Russian youth nanotechnology prize and the winners of the international scientific papers contest for young scientists working in the field of nanotechnology.

Rosnanotech2010 brought together more than 10 thousand participants from 50 countries. During the Business and Science and Technology programs of the Forum, more than 400 presenters spoke. These speakers include Nobel Prize winners Academic Zhores Alferov, Professor Konstantin Novoselov, provost of the Massachusetts Institute of Technology Rafael Reif, and General Director of Microsoft Steve Ballmer. The plenary session of the Forum was opened by the president of the Russian Federation, Dmitry Medvedev. Hundreds of Russian and foreign companies have presented their designs at the Forum’s exhibition. More detailed information about the Rosnanotech2011 forum is available on the website: www.rusnanoforum.ru

[*An R&D center for composite materials will be opened at Skolkovo*, Rosnanotech, 26 octobre 2011]

1 Nanotechnology in the service of medicine, co-investisseur rosnanotech, 19 juillet 2010

Russian nuclear physicists at the “Alpha” Research and Production Facility in Dubna have developed an advanced apparatus for plasmapheresis. There is no analogous apparatus elsewhere in the world. According to the developers, the purification of blood using nanotechnology saves the lives of Russians from atherosclerosis and many other serious illnesses.

There is a need to remove toxins from blood to treat atherosclerosis. The plasmapheresis removes cholesterol and lipoproteins that forms plaques in the inner lining of the arteries. Russians use only imported equipment to follow this procedure, and it costs about 1, 000 U.S. dollars per patient. The development by the scientists in Dubna makes the treatment accessible for a large number of patients since it is several times cheaper than the foreign technology.

The Russian scientists suggested using a nano-filter for plasmapheresis. It is made out of a film similar to one which is used in the food industry. The film is placed in a cyclotron where it is subjected to the bombardments of argon atoms. Then it is placed in alkaline to create nano-holes at the places where atoms hit it. In the end, we get a punched film with 200 nanometer diameter holes. In fact, the diameter of a hole is 250 times less than that of a hair.

When blood passes through such a membrane filter, it is separated into parts, erythrocytes settle on the membrane and plasma, the basic bearer of viruses and antibodies, is removed, says an expert at the “Alpha” Centre, Yuri Prytkov.

“Plasma passes through the membrane, and blood bodies are separated and return to the patient,” says Yuri Prytkov. ”The “Alpha” Research and Production Facility has started producing these apparatuses, which are quite compact. In this case, a centrifuge is not used to separate blood, and consequently the apparatus can be used also in field conditions. This is portable equipment and experts can carry it to a patient and do plasmapheresis at his home. It can be used by the military, rescuers and services for disaster medicine.”

The state-run “Rosnanotech” is the co-investor of the project that has already allocated 1.3 billion rubles or 43 million U.S. dollars to implement it. This sum will be used to build a facility to start the production of the apparatuses for cascade plamapheresis. According to estimates, this sum will be paid off in 4-5 years. According to “Rosnanotech” the development by Dubna scientists is an example that Russia’s scientific potential is being turned onto the commercial track.

http://english.ruvr.ru/2010/07/19/12759176.html

2 T-Platforms Group Chosen to Manage $6 Million Nanotechnology and Supercomputing Enablement Program, 31 st 2010

Applicants selected by a RosnanotechExpert Council will receive 75% funding for approved projects.

T-Platforms Group, a leading provider of HPC systems, software, services and solutions, was chosen by the Russian Corporation of Nanotechnologies, Rosnanotech, to lead the program management and execution for a competitive solicitation that will provide collaborative funding and development support for at least 20 nanotechnology-related computational tasks and 20 computational tasks from industrial production organizations. The industrial production tasks will be selected from specific industries targeted by this program to include engineering in areas such as shipbuilding, aerospace, automotive, oil and gas, chemistry, pharmaceuticals, energy and construction.

As part of this program, worth $6 million over a ten-month period, T-Services, a T-Platforms Group company acting as program manager, will evaluate applicants based on criteria such as potential importance, practicality, possible ROI, and applicability to spawning commercially sound results or products. Organizations will go through a two-stage process, and those selected for this program by the Expert Council under the leadership of Rosnanotechwill receive 75% of the funding of the total computational project costs. T-Platforms, another T-Platforms Group company, will provide T-Services with a dedicated cluster for this project.

The Nanotechnology and Supercomputing Enablement Program has been designed to create a supercomputing service infrastructure based on end-to-end guidance, support and professional services. This is a significant effort on behalf of the Russian government to establish a robust commercial market for supercomputer simulations – an approach that could have a significant impact on improved production and productivity for many industrial / commercial market segments.

“The vision and leadership of Rosnanotechdemonstrates this country’s keen understanding of the vital importance of supercomputing and the impact scientific and engineering discovery will have on the future of this planet,” said Vsevolod Opanasenko, CEO of T-Platforms Group. “We are pleased to have been selected for this very important project and look forward to our collaboration with Rosnanotechand our other program partners as we strive to eliminate many of the barriers to widespread HPC adoption.”

T-Services will work in close collaboration with the Joint Supercomputer Center of the Russian Academy of Science, the Computational Center of Moscow State University (MSU), Vladimir University, and Tomsk University to provide needed supercomputing resources.

Evgeny Evdokimov, Managing Director of Rosnanotech, said: “This program allocates funding to help organizations developing products or technologies that are deemed important for future productivity. Advancing the use of supercomputing for modeling and simulations has been identified as a vital competitive element to advancing scientific and engineering discovery, and we are pleased to partner with T-Services on this leading edge program.”

“The Rosnanotechprogram is seeding the scientific discovery efforts within Russia, but more importantly, it can be seen as a potential forerunner for a new way of funding and managing large-scale HPC projects,” said Addison Snell, CEO of InterSect360 Research, a market research and consulting company dedicated to the worldwide HPC industry. “Rosnanotechrecognizes HPC as the enabling technology for scientific and engineering progress, and it matches the responsibility of HPC stewardship with the expertise of T-Platforms. This takes us a step closer to HPC as a service for large-scale deployments, which could have long-term benefits for scientific and commercial productivity.”

About T-Platforms:

Established in 2002, T-Platforms Group is rapidly emerging as one of the leading global HPC companies, providing comprehensive supercomputing systems, software and services, with customer installations consistently included on the TOP500 worldwide list of the most powerful supercomputers.

T-Platforms Group consists of T-Platforms, T-Services, T-Massive Computing, and T-Design, with locations in Hannover, Moscow, Kiev and Taipei.

About Rosnanotech:

The Russian Corporation of Nanotechnologies (Rosnanotech) was established in 2007 by the Russian government as a state corporation that co-invests in nanotechnology industry projects that have high commercial potential or social benefit.

Grand Prix of the Federal Russian Competition “Russian Innovations”, 9 juillet 2010

The Scanning Probe Microscope SOLVER NEXT – the Product of NT-MDT Co. – got the Grand Prix of the Federal Russian Competition “Russian Innovations”

The Competition “Russian Innovations” is 9 years old. It is held by authoritative Russian media holding “Expert”. The partners of the event are the main nano-organizations in the country “Rosnanotech” and “ROSATOM”. The competition is an essential part of Russian innovation and nanotechnology development program. It plays a very important role in launching and promoting new high-tech developments in Russia and worldwide. Getting publicity to nanodevelopers and producers, the event increases investing rate in nano-sector. Moreover, the competition helps to expertise new tools and ideas and to select only perspective ones. So, it raises the confidence rate to nano-sector in Russia.

The Scanning Probe Microscope SOLVER NEXT has managed to receive Grand Prix of the “Russian Innovations-2010”. Its producer NT-MDT Co. names it “the state-of-the-art company’s development”. This tool offers both atomic force (AFM) and scanning tunnelling microscopy (STM) under one hood. This enables researchers to gain the fastest time to results, excellent performance, increased accuracy, high reliability and unprecedented ease-of-use with no loss in resolution. The flexible, sleek and functional system incorporates smart software, automated head exchange, and motorized sample positioning under video monitored control. This allows for high quality images without the need for specially trained operators.

The system has closed-loop sensors to compensate for inherent piezoelectric imperfections such as scan nonlinearity, creep and hysteresis. With two additional removable heads for operating in liquid environments and nano-indentation one has the freedom to work with a variety of samples, measuring modes and conditions. The SOLVER NEXT has an advanced controller with a vast library of scripts and both Mac® and Windows® compatibilities. The result is an image-friendly operating system well-suited to large file, 3-dimensional mathematics and manipulation.

So, the tool is designed to meet a researcher's current and future needs. This innovative device at the forefront of scientific research opens up new paths of study in different fields of nanotechnology, providing all user levels with a full range of conventional SPM measuring techniques (such as topography, phase imaging, nanolithography and more). SOLVER NEXT provides a robust, diverse, and economic solution for universities, industrial, routine biological and pharmaceutical labs. It makes AFM and STM accessible to a broader audience, even offering a special iPhoneTM applet for simple image analysis and image sharing.

Innovation Lift at Work: Rosnanotechto Support Production of Anti-aging Nanocosmetics28.10.2011

Rosnanotechis joining a project that will produce cosmetics based on double encapsulation technology. Earlier, the project attracted financing from Russian Venture Company's Seed Investment Fund. The project has a total budget of 65 million rubles. Rosnanotechwill receive an 18% interest in Nanoderm-Profi, the project company.

The project will produce anti-aging cosmetics, skin cleansing agents, and professional agents for cosmetic salons. The technology underlying production was developed in Ufa, Republic of Bashkortostan, by Zhespar-Bios and the Ufa Science Centre's institutes of Biology and Biochemistry and Genetics, both affiliates of the Russian Academy of Sciences.

The cosmetics are non-toxic and highly effective, thanks to the technology of double encapsulation. The active ingredient—uronic acid—is embedded in nanoparticles of cyclodextrin of less than two nanometers. Those particles are, in turn, surrounded by a spherical capsule of beta-cyclodextrin and plant-based lipids with diameters of 80 nanometers. When the nanostructures are applied to the skin, the external capsule dissolves and the nanoparticles of cyclodextrin transport the active ingredient through the transdermal barrier to the skin's deep layers.

Project company Nanoderm-Profi is already producing and selling the first series of its nano-cosmetics. Earlier, the agent passed organoleptic, physiochemical, microbiological, clinical-laboratory, and toxicological testing by Rospotrebnadzor, Russia's Federal Service for Supervision of Protection of Consumer Rights and Human Welfare. As this project develops, Nanoderm-Profi plans to expand its assortment of active components.

"The project to produce anti-aging cosmetic agents won investment from the Seed Investment Fund of Russian Venture Company at the early stage of development. Today we have signed documents for a new large round of investment with Rosnanotech. In our view, this demonstrates two important things," said Yan Ryazantsev, director of the Department for Investment and Expertise, Russian Venture Company. "First, that cooperation among Russian institutions for development is in a healthy spot. And second,that an important element in technical entrepreneurship—innovation lift—is fulfilling the goal set for it. We are confident that Nanoderm-Profi, with the entry of Rosnanotechas an investor, will develop more rapidly and with greater success."

"Nanocosmetics is one of Rosnanotech'sproject areas where production directly serves the consumer. We are interested in ramping up the project and participating in the next stages of its development," Rosnanotechmanaging director Konstantin Demetriou explained.

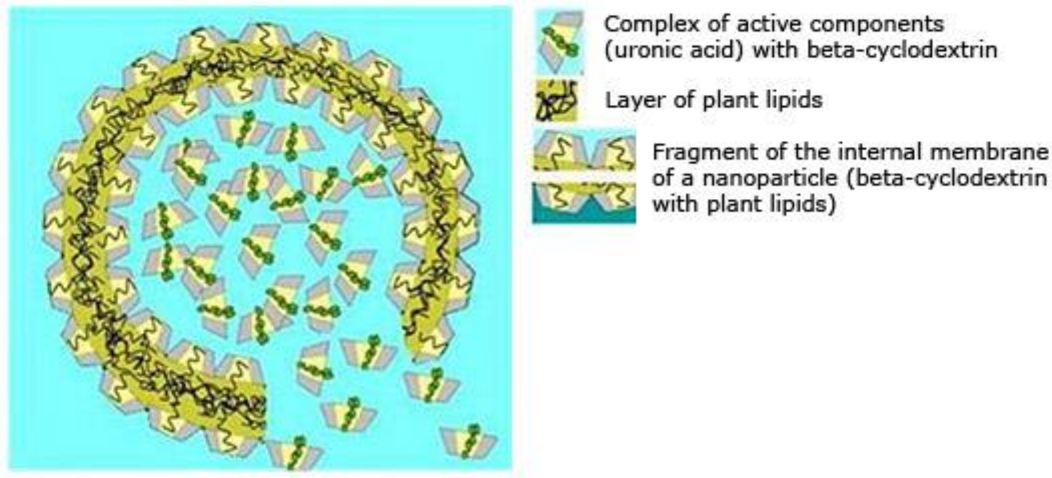

Diagram of double encapsulation of the active component of a nanoparticle of cyclodextrin and an outer cyclodextrin nanoparticle capsule with a layer of plant-based lipids

[Innovation Lift at Work: Rosnanotech*to Support Production of Anti-aging Nanocosmetics,*Rosnanotech, 28 octobre 2011]

Appendice 4 : Russia building its own "Silicon Valley"

23 June 2010

Russian president **Dmitry Medvedev** flew to California this week to drum up support for his country's attempt to build an entrepreneurial enclave just outside Moscow.

He met with California governor **Arnold Schwarzenegger** on Tuesday, and plans to meet with the founders of Twitter, as well as Google CEO **Eric Schmidt**, before meeting US President **Barack Obama** in Washington D.C.

Over the past four months, Russia has been building it's own version of California's Silicon Valley, called the Skolkovo 'innovation city.'

"I want to see how things work on Silicon Valley. We would like to create something similar in the Russian Federation – adjusted to suit our views, of course," Medvedev said in a Wall Street Journal interview.

To reduce its economic dependence on natural resources such as oil and natural gas, Russia has been pouring its efforts into high tech development. The government created a company called Rosnanotechto invest in nanotechnology, and has been supporting regional venture funds to invest in tech companies.

Medvedev also plans to meet with representatives with Cisco Systems, **Yuri Milner**, CEO of Russian investment firm Digital Sky Technologies, and **Arkady Volozh**, CEO of Yandex, Russia's largest search engine.

Social Times by Kenneth Musante

Appendice 5: very substantial financial resources for R&D, the Federal Targeted Programs

The federal target program "Research and Development as priority directions of growth of the Russian scientific and technical complex 2007-2012", based on the order of the Government of Russia July 6, 2006, is primarily coordinated by the Ministry of Education and Science. Other concerned government agencies are RosNauka (Federal Agency for Science and Innovation), RosObrazovanie (Federal Agency for Education) and MGOu (State University Lomonossov Moscow).

It can be presented following five priority thematic orientations: living systems, nanomaterials and nanotechnologies, ICT, rational use of natural resources and energy efficiency.

The program is divided into two stages. Between 2007 and 2009 efforts should focus on accelerating the commercialization of technologies prioritized by the Russian President, by attracting additional resources. Between 2010 and 2012, efforts will focus on the development of structures and mechanisms to support long-term innovation.

Nanotechnologies represent 40% of the planned R & D funding following the Federal Targeted Programme for 2007-2012, almost € 1.25 billion over 6 years, increasingly (€ 143 million in 2007 and an annual growth of 25 %). In addition, research in the field of nanotechnology are not conducted only in the context of this federal target program, but in applications "off budget" for the work done by the institutes of the Academy of Sciences of State and by higher education institutions, in the quote by funding framework. Thus, within the Presidium of the Academy, two programs concern nanoscience, materials and on the electronic equipment.

The program has set a number of priorities for R&D (2007-2012):

- Accelerated development of scientific and technical potential,
- Realization of priority directions through major marketing projects in technology,
- Consolidation and concentration of resources through expansion of public-private partnership mechanisms, for example by stimulating R&D orders from the private sector,
- Encouraging the inflow of young specialists to the R & D, development of major scientific schools,
- Development of research activity in universities and graduate schools,
- Support the development of innovative SMEs and their integration into the system of scientific and technological cooperation,
- Development of a base of competitive scientific organizations conducting basic and applied research,
- Development of effective infrastructure elements of the innovation system.

These qualitative objectives are accompanied by quantitative targets (over the entire duration of the program):

- Additional production of high-tech products: € 4.3 billion for the commercialization of technologies developed,

- Export additional high-tech products: 1.1 billion €,

- Attraction of non-budgetary resources: 1.7 billion €,

- Increase in domestic expenditure on R & D, including off-budget: 4.9 billion €,

- Development 127-136 competitive technologies for marketing,

- Implementation from 8 to 10 commercial technology vanguard,

- Implementation from 5 to 8 critical technologies in which Russia will own the global primacy,

- Creation of 6 to 12 new organizations, providing a basis of scientific equipment worldwide,

- Creation of 36 500-41 000 new highly skilled positions,

- Theme from 20 000 to 23 500 young specialists in research and development,

- and improvement of a series of indicators: annual increase in GDP of 0.018 -0.023 points ; annual increase in the share of domestic expenditure on R & D in GDP of 0.05 to 0.09 points ; annual increase of the share of non-budgetary funds in internal expenditure on R & D of 0.7-1.3 point; annual increase of the share of innovative companies among the industrial enterprises of 1.1 to 3.6 point ; annual increase in the share of high-tech production in the volume of industrial production from .04 to .12 points ; increase in the proportion of researchers under 39 years of 1.8 points ; passage of the budget efficiency coefficient Program at 45-50%.

The program was designed as a compromise between three variants:

· Evolution: direct application of measures and mechanisms implemented the previous program (2002-2006),

· Investment: training centers of excellence and development of scientific and technical basis,

· Partnership: developing public-private partnership mechanisms, attraction of new investors.

The total budget (value in the respective years) of the program is € 5.6 billion, 69% of the federal budget.

The amounts are revised annually.

The program is divided into five blocks of measures:

· Generation of knowledge

· Development of technologies,

· Technology Commercialization,

· Institutional research and development base,

· Infrastructures for Innovation Systems.

Appendice 6 : Appendice 6 : ARCUS programme and the Seminar

The ARCUS Program in Lorraine with the MISIS in Moscow

The Lorraine/Russia project fits part within the framework of scientific cooperation initiatives in recent years between the laboratories of universities in the Region Lorraine and laboratories of the Russian Federation in the field of materials science. Adds a thematic dimension on plasma physics and environmental risks with a collaboration with the PACA region, which will host the ITER project.

The main russian partner is the MISIS (Moscow's Institute of alloys and metals), but more than a dozen other institutions are also involved, including:

- Russia's University of Chemical Technology Mendeleev D.E. (RKhTU),
- Moscow's Physical Institute of the engineer (State University) (MIFI),
- Electronic Technical Institute of Moscow (Technical University) (MIÈT),
- Irkutsk State Technical University (IrGTU),
- Ural State University A.M. Gorky (UrGU),
- Taganrog State University of radio engineering (TGRU),
- RAS Institute of Metallurgy and Materials Engineering A.A. Baikov (IMET),
- RAS Institute of Geology of deposits, petrography, mineralogy and geochemistry (IGEM),
- RAS Institute of Complex development problems of basement (IPKON),
- RAS Institute of solid Physics (IFTT),
- RAS (Ural Branch) Institute of the Continuum Mechanics,
- Institute for Research and Engineering "enrichment technology of mineral raw materials" (TOMS), Irkutsk.

The entire project also will has a total budget of € 0.6 million for three years (2006-2008), distributed as follows: € 0.35M of the Foreign Ministry; € 0.25M in the Lorraine region.

The project is divided into five subprojects, two of which concern nanomaterials:

- subproject 2 "**Materials, surfaces, interfaces**" with two lines of research: the relationship between microstructure and performance and surface treatment to advanced features,
- subproject 3 "**Nanomaterials and Nanotechnologies**", with two areas of research: the development of new composite carbon nanotubes and their characterization and development of materials for optics and optoelectronics.

Both actions cover about eight fairly active cooperations, and might lead to technological applications.

SHS ("Selfpropagating High temperature Synthesis") with Chernogolovka

The RAS Structural Macrocinétique Institute (ISMAN) of Chernogolovka has recently started strong collaborations with France (Universities of Dijon, Nancy, Montpellier, Poitiers, Limoges, Villetaneuse, forming a Reserach Group "Auto Ignition" until 2004) on the method SHS ("*Selfpropagating High temperature Synthesis*") which enables the production of new materials on which the Russians have an excellent command. Complementarity with the French side is in its capabilities of characterization and use of these materials. The industrial applications are numerous (refractory, hardening deposits, ultra hard materials, heat shields, etc.). These collaborations have been initially included into a request for PICS International Program with the CNRS, with the goal of achieving eventually a joint laboratory "without walls" with Dijon, where an international symposium was held in 2007 on SHS.

The establishment of an annual seminar in exploratory vocation

The SSTE, in conjunction with the Ministry of Education and Science of Russia organized in 2004 the first "Franco-Russian Seminar on Nanotechnology" at a remarkable level, with more than twenty French participants with a focus to develop concrete partnerships or create "binômes" of Franco-Russian technological research. The Institute of Crystallography "Shubnikov" (ASR) has played an important role in the first Seminar coordinating with the Embassy and its organization by welcoming delegates of bilateral seminar. Two other seminars followed, respectively in Lille (2005, coordinated by the IEMN) and St. Petersburg (2006, coordinated by the Ioffe Institute), around three themes identified jointly: **spintronics**, **carbon nanotubes and Terahertz waves**. For 2007, a new focus on **photonics** should be developed at the seminar to be held in Grenoble.

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