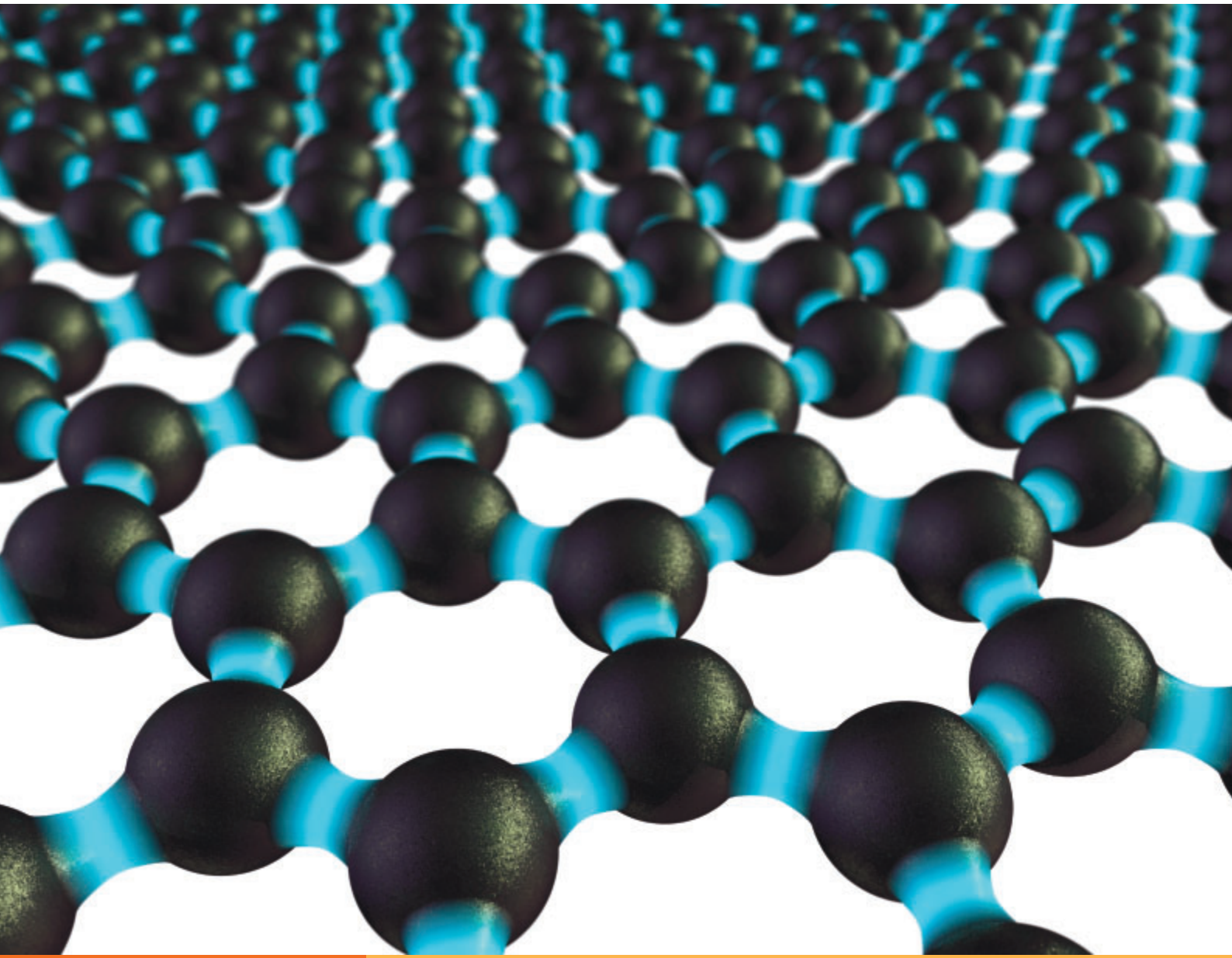
Federal Ministry
of Education
and Research

IDEAS
INNOVATION
PROSPERITY
The High-Tech Strategy for Germany

Action Plan Nanotechnology 2015



HIGH-TECH STRATEGY

Igniting ideas!

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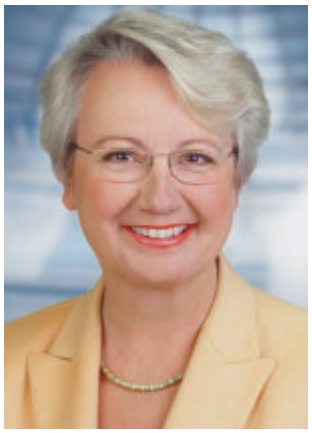
Preface



Key technologies are opening the door to Germany's future. They are the basis for new products, processes and services. They point out solutions to the global problems of our time. We must ensure the successful transfer of scientific knowledge to industrial applications. And we must ensure that the resulting products are safe for our health and the environment. Only safe products can provide lasting economic opportunities.

These aspects are particularly relevant for developments in nanotechnology. The technological performance and international competitiveness of German industry strongly depend on nanotechnology. Nanotechnology will make a major contribution to progress in the health sector and agriculture, in energy and resource efficiency, in environmental and climate protection and in the field of civil security.

The research institutions, economic activities and regulations that are relevant in the context of nanotechnology are equally diverse. But we still know too little about the impact that nanomaterials will have on human health and the environment.

The Federal Government's "Nanotechnology 2015 Action Plan" carries on from the "Nano-Initiative – Action Plan 2010". Under the umbrella of the High-Tech Strategy, we are presenting a concept that pools lines of action and fields of application in the context of nanotechnology. We are focussing research and research funding on the societal challenges addressed in the High-Tech Strategy, i.e. climate and energy, health and nutrition, mobility, security and communication. Economic exploitation, responsible use, a regulatory framework and a public discussion are other important factors.

The Federal Government supports the use of nanotechnologies to secure economic and social progress in Germany. We will thereby carefully balance the opportunities and risks on our way to reaching our goal of a nanotechnology sector that is both safe and sustainable.

Prof. Dr. Annette Schavan, Member of the Bundestag
Federal Minister of Education and Research

Content

1 Introduction

Nanotechnological applications are already having an impact on a number of products and processes. New functional properties of objects and material structures with dimensions in the nanometer range, generally below 100 nm [1], are specifically exploited [2]. Thus new electronic, magnetic and optical properties of materials are generated: melting points are shifting, but also catalytic activities, solubility and transport properties of substances become dependent on size.

The term "nanotechnology" was forged in the 1970s by the Japanese Norio Taniguchi. He described manufacturing methods with a precision in the nanometer range. The American physicist and Nobel Prize winner Richard Feynman, however, is still regarded as the father of nanotechnology. Already in 1959, he forecasted the technical possibilities of the nanoscale in his speech "There's plenty of room at the bottom".

The increasing economic and societal importance of nanotechnology was taken up by seven departments of the Federal Government already in 2006. With the "Nano-Initiative – Action Plan 2010", a harmonized action framework across all ministries was presented for the first time, which pooled under one umbrella the different – sometimes even conflicting – approaches from SME-support, new lead innovations over enhanced risk research up to a comprehensive dialogue with the public regarding the chances and impacts of nanotechnology. The joint action and coordination of the departments' activities provided a basis, on which nanotechnology in Germany could be perpetuated and the high research standard could be further developed. At the same time, discussions on nanotechnology were continued by conducting intensive dialogues with different groups of society; anxieties were taken into account and taken into consideration for further orientation, in particular in research and development.

The scientific and economic potential of nanotechnology is still considered to be high. At the same time, there is still a lack of knowledge regarding the possible impacts. Here are the challenges for the Federal Government to use the chances for innovations, research and development and to simultaneously protect humans and environment.

With a high number of applications, nanotechnology has found its way into almost all branches of industry. While at the beginning of the millennium, most applications of nanotechnology were still limited to particular technical products, there is now also an increasing use in everyday products and consumer goods. Parallel to this, a comprehensive discussion on chances and risks of nanotechnology has started among the societal groups. Another focus of attention is the regulation of nanomaterials-containing products. It is currently being examined to which extent the European and national legal frameworks need to be adapted to the use of nanomaterials in products in order to ensure consumer safety. An amendment of the European Cosmetics Directive has already been adopted: The labeling of nanomaterials in cosmetics will be obligatory from 2013.

The incorporation of nanotechnologies in legal regulations has raised the question of a justiciable definition of nanomaterials beyond a purely technical-scientific approach. The first definition comes from Norio Taniguchi who in 1974 defined: *„Nanotechnology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule"* [3]. The only enacted definition so far is that included in the EU-Cosmetics Directive: *"Nanomaterial: an insoluble or bioresistant and intentionally manufactured material with one or more external dimensions, or an internal structure, on the scale from 1 to 100 nanometers* [4]. An internationally harmonized definition has not been adopted so far; however, a number of different definitions are under discussion [5].

2 Strategic Goals of the Federal Government

Germany is an export-oriented country, which is poor in natural resources and whose competitiveness is closely linked to future markets. Therefore, coordinated innovation politics of the Federal Ministries is required, in particular in fields like nanotechnology. Successful innovation depends on good cooperation of all actors. This requires responsibility in research, education, economy and politics. In order to comprehensively use the potentials of nanotechnology for Germany, the Federal Government presents the "Action Plan Nanotechnology 2015", which forms the common platform for the safe, sustainable and successful handling of nanotechnology in all its facets.

The Federal Government has set itself the goal

- **to use nanotechnology to contribute to growth and innovation in Germany.**
  With a GNP decline of 4.8% in 2009, the business location of Germany was hard hit by the global economic and financial crisis. In particular exports had to register a historical decline of about 19%, as a result of which Germany had to cede the title as export world champion to China. Germany's economic future will also decisively depend on how the opportunities of key technologies will be seized. There is hardly any high-tech-product available on the world market, the production of which did not involve nanotechnological processes and components. For 2015, the global cross-sector market volume nanotechnology might be able to influence is estimated at over one billion Euro. With a research quota of 14% of the R&D-spending in relation to the total turnover, the nanotechnology sector belongs to one of the most innovative fields of technology in Germany. Therefore, one of the Federal Government's goals is to securely and sustainably boost nanotechnological innovations in order to strengthen the German economy and to provide benefits for the citizens.

- **to make nanotechnology safe and sustainable.**
  Nanotechnology is more and more found in everyday products and consumer goods. Industry is obliged to launch only those products which are safe and harmless when used by the consumer. Even if it must be assumed that this applies to the nanotechnology products currently available on the market, there is little transparency in the public regarding the questions of which products really contain nanomaterials and what the consequences might be. Due to the increasing use of nanomaterials in consumer products, the possibility of their entry into the environment increases as well. Accordingly, it is necessary to advance exposition scenarios, product or particle-specific risk assessments and ecotoxicological analyses.

Therefore, the Federal Government plans to contribute to the clarification of the impacts of nanomaterials on humans and environment, to research their potential risks and, if required, to establish the respective risk management. For that purpose, the Federal Government is planning the corresponding growth of the required funds.

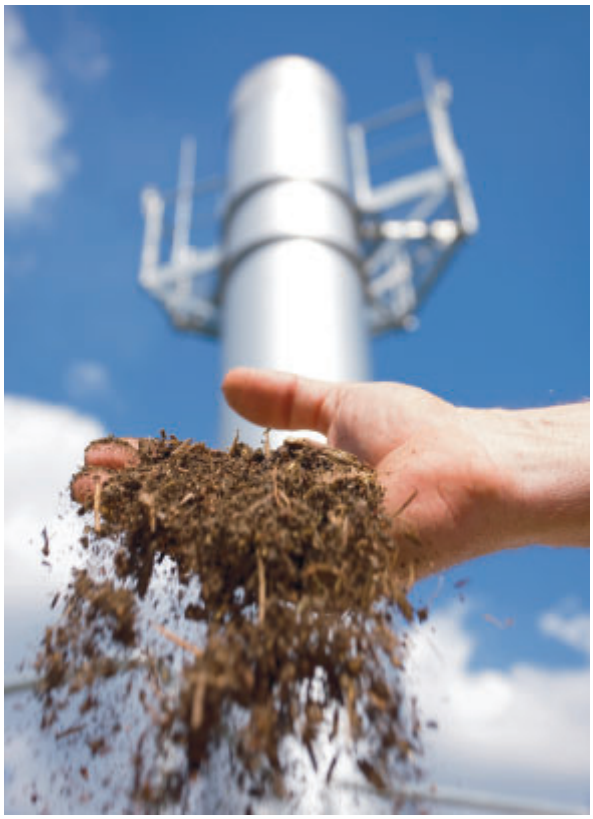
- **to tap the potential of nanotechnology in education and research.**
  Research and innovation are indispensible for Germany. The basis for it is well-trained specialist staff and an active, excellent research landscape. Nanosciences and nanotechnology provide comprehensive opportunities for that. Due to their interdisciplinary character new research fields and approaches are opened up, new occupational profiles emerge. On the one hand, the proven research landscape and a close-meshed network of infrastructures provide the basis for the industrial exploitation, on the other hand, they also address questions arising within the framework of new economic developments. Moreover, both science and economy give new impulses for education and training to fulfill the requirements of nanosciences and nanotechnology. In future, the Federal Government will also support measures which help expand the technology location of Germany, which promote young talents and create competences and infrastructures.

- **to tap the potential of nanotechnology to meet global challenges.**
  The High-Tech-Strategy of the Federal Government focuses on the global challenges climate/energy, health/nutrition, mobility, security and communication, which require future solutions. Germany shall take a pioneering role and give convincing answers to the pressing questions of the 21st century. Nanotechnology and other key technologies provide technological approaches to cope with concrete challenges.

This is how the Federal Government wants to

- **secure the contributions of nanotechnology to the protection of environment and climate, to the securing of energy supply and to the creation of a knowledge-based bioeconomy.**
  The use of nanoscale materials and effects opens up potentials for resource- and energy-efficient products and processes. This includes environmental technologies for the removal and avoidance of noxious substances, procedures of product-integrated environmental protection with optimized energy- and material flows as well as efficient methods of conversion, storage, distribution and use of energy. Innovations deriving from nanotechnology research shall help Germany to develop into a lead market and export nation for energy- and resource-saving products. In particular, the development of

a knowledge-based bioeconomy can achieve sustainable raw material and energy supply from biomass. So with the increasing diffusion of bio-based procedures in traditional branches of industry, such as the chemical, pharmaceutical, paper or energy industry, also nanotechnology will be applied and can make important contributions to the achievement of the sustainability goals of the Federal Government.

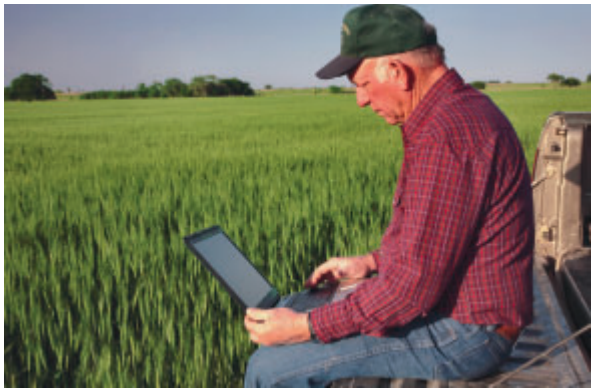


Fine chaff material for power and heat generation

- **utilize the possibilities of nanotechnology for health.**
  Health is a topic that touches and moves people all over the world. However, despite intensive research, the interrelation between genetic disposition, environment and lifestyle are often still not understood in pathogenesis. In addition, diseases like metabolic disorders, cancer, cardiovascular problems or dementia occur more frequently due to changed living conditions and increasing life expectancy. New methods of prevention, diagnosis and therapy need to be researched; methods of individualized medicine will gain importance. The application of nanotechnologies in medicine can give new and effective impulses to health care. Nanoparticles provide new technical solutions which help to diagnose diseases earlier, to heal damaged tissue and to more effectively transport drugs to where they are intended to take effect.

- **use the possibilities of nanotechnology for sustainable agriculture and food safety.**
  Increasingly more stringent limiting values, documentation obligations and production requirements call for highly precise methods in wide areas of intensive agriculture and forestry as well as in animal husbandry, which can only be implemented by means of electronically precisely controlled and documented production procedures. Nanotechnological developments can contribute decisively to optimized electronic control technology. In the field of plant protection, nano-encapsulated substances can be applied considerably more efficiently and environmentally friendly when they fulfill the legal requirements. The precondition for the application of nanomaterials in agriculture is the risk assessment of the changed properties of the active substances and the carriers. Potential fields of application are also to be found in the production and processing as well as in the analysis and quality assurance of food and feeding stuff. Research is made into the possible positive effect of nanoparticles on hygiene and the shelf life of food, which could thus contribute to the reduction of serious post-harvest losses. As things stand at present, the direct application of nanotechnology to food and feeding stuff as well as to their ingredients

does not yet take place in Germany and will only be approved after careful consideration of safety issues.



- **achieve environmental and energy-saving mobility through nanotechnology.**
  Due to dwindling fossil resources, alternatives to combustion engines need to be found. The future belongs to the electric drive. It is the goal of the Federal Government to develop Germany into the lead market for electric mobility. With the "National Electromobility Development Plan", measures are presented which shall create the framework conditions for one million electric vehicles in Germany by 2020. For this purpose, modern electric drives and energy stores must be explored und developed. Nanotechnological insights are important for the manufacturing of rechargeable batteries and high-capacity super-capacitors. Moreover, nanotechnology is of great importance for other alternative drives, as for example in the development of materials for hydrogen storage and of components for the development of fuel cells.

3 NANOTECHNOLOGY IN GERMANY – AN OVERVIEW

3.1 The Image of Nanotechnology – Transparency and Information

The comprehensive information of the public about the pros and cons of nanotechnological materials and applications is very important in order to objectify the discussion on the use of nanotechnology. In this context, the orientation towards the legitimate expectations of the citizens as well as the open dialogue with politics, economy and society are significant concerns.

With regard to everyday products, it is important to make consumers more familiar with nanoproducts and to explain how and why nanoscale material is used. Therefore, the properties of products with nanoscale components need to be properly imparted and the handling required for safe use needs to be clearly explained. This is the only way to ensure an objective risk discussion, which avoids both global promises and the global rejection of synthetic nanomaterials.

Consumer surveys and findings of investigations regarding risk perception show that the state of knowledge about nanotechnology among the population is still rather low [6]. A differentiated enquiry has shown that nanotechnology is mainly accepted in the medical field and in surface sealing.

The closer nanoproducts get into direct contact with the body (e.g. textiles and cosmetics) the lower is their acceptance. The same applies if they get into the body without showing clear benefits (e.g. food), as in case of medical applications. Further surveys on the image of nanotechnology among the population as well as public discourses and offers regarding risk communication with the involvement of politics, science, economy and stakeholders shall facilitate future orientation and contribute to the responsible handling of nanotechnology.

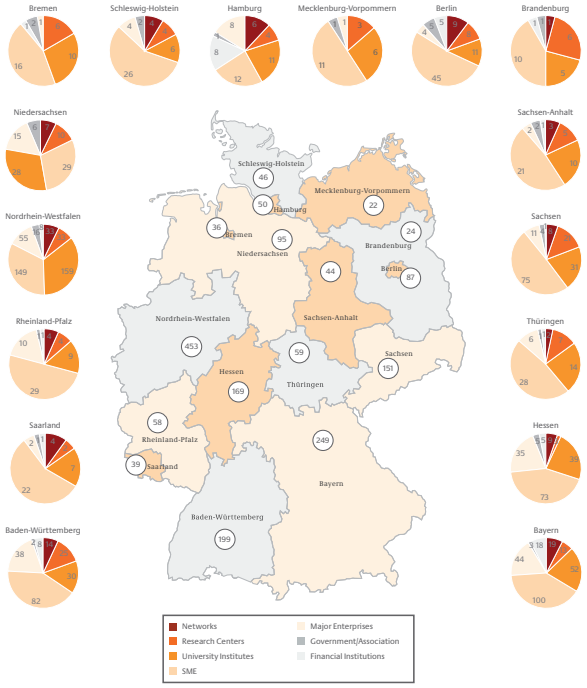
3.2 Status Quo of Nanotechnology in Germany

The commercial relevance of nanotechnology is mainly to be seen in its pacemaker function. As an “enabling technology” it sets in at an early stage of the value added chain. New production approaches, new materials and new components enable more efficient products. Germany also has a good position in nanotechnological basic research. Moreover, there is a broad industrial basis for the exploitation of research results.

Research landscape

In the field of basic research, the institutes of the Max-Planck-Society and the Helmholtz Association belong to the world’s leading institutions in the fields of nanotechnology. Also the Fraunhofer-Gesellschaft and the scientific community Leibniz-Association are well-positioned and attentively monitor the application-relevant implementation activities. Moreover, experts of nearly all German universities with technical-scientific focus are working on nanotechnological issues. Here, both applications of nanotechnology and their impact on humans and environment are surveyed.

A network of **Fraunhofer-Institutes** is focusing on the joint solution of questions regarding multifunctional layers, on the design of special nanoparticles and on the application of carbon nanotubes within the framework of the Alliance Nanotechnology. The Photocatalysis Alliance deals specifically with the development of photocatalytically active coatings based on nanoparticles, addressing also environmental aspects. In the field of key technologies, the activities of the **Helmholtz Association** aim at the integration of



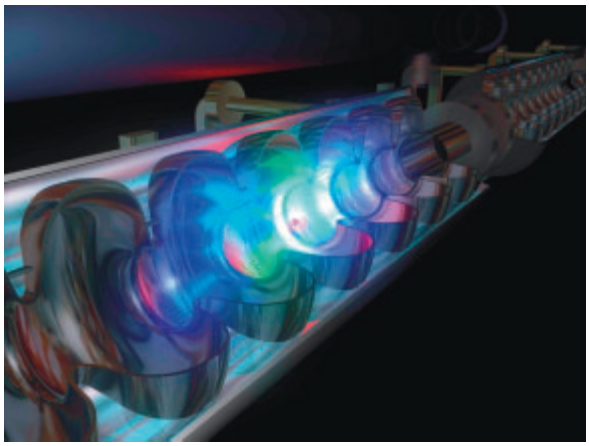
Nanotechnology-related organizations in Germany (www.nano-map.de)

nano- and microsystems. Regarding the topics of nanomaterials and processes, the Nano-Micro-Facility was opened in Karlsruhe, which, as a user facility, is available to all Helmholtz institutions. The Helmholtz Center in Munich deals in particular with issues regarding toxicology. Several **Max-Planck-Institutes** have already been working for years in the fields of nanomaterials, supramolecular systems or characterization methods. Also, the **Leibniz-Association** can rely on numerous institutes with excellent results in research into nanomaterials, surfaces and opto- and nanoelectronic properties.

Within the framework of the **excellence initiative** of the Federal Government and the Länder, future concepts, so-called excellence clusters and post-graduate research programmes, are funded, which contribute to profound nanotechnology-relevant education and excellent research results. Furthermore, the Federal Government supports R&D-measures for the development of competence in electrochemistry within the framework of the Second Economic Stimulus Package.

Research infrastructures

In the field of **infrastructures and large-scale facilities,** the Federal Government has been funding national photon and neutron sources for more than thirty years, which have become indispensible for basic research into nanotechnology. Thus in the international comparison, German scientists have a broad range of excellent research facilities at their disposal.



Superconducting resonators for the electron acceleration in a free-electron laser (XFEL)

Multifunctional nanomaterials in their complexity exceed the characterization possibilities of individual laboratories and require a comprehensive interdisciplinary approach. Here, the results of research with synchrotron and neutron beams are indispensible. The photon and neutron sources provide a unique potential for the in-situ survey of the most different processes in different time and space dimensions. Therefore, such large-scale facilities provide the possibility to achieve a comprehensive understanding and thus the control of relevant processes in nanosciences [7].

Infrastructures in Germany:

- Photons ("Synchroton radiation"):
  - DORIS, PETRA III, FLASH – DESY Hamburg
  - BESSY II – HZB Berlin
  - ANKA – KIT Karlsruhe
- Neutrons
  - FRM II – TUM Munich, Branch FZJ, GKSS and HZB
  - BER II – HZB Berlin
- Charged particles (nuclear probes and ion beams)
  - UNILAC / SIS18 – GSI Darmstadt
  - FRM II / Positron source – TUM Munich

European sources with German participation:

- European XFEL – Hamburg (photons)
- ESRF – Grenoble (photons)
- HFR – ILL Grenoble (neutrons)
- ISOLDE – CERN, Geneva

Departmental research

Also **Federal Research Institutes** are focussing on nanotechnology. Safety research is particularly significant in the field of work protection, since the persons involved in the development and production of nanomaterials are the first to be faced with the impacts of the new technology. For this reason, the **Federal Institute for Occupational Safety and Health (BAuA)** is working on projects in the field of nanotechnology and work protection. The **Federal Institute for Risk Assessment (BfR)** deals with the evaluation of possible health impacts of the application of nanotechnology and publishes the results within the context of the risk communication, inter alia, in its Internet presence. Moreover, the BfR organizes publicly relevant projects with regard to nanotechnology. The **Federal Institute for Materials Research and Testing (BAM)** makes decisive contributions by developing test methods and reference materials within the framework of its mandate "Safety and Chemistry". It provides its scientific know-how for the standardization and thus boosts quality assurance in nanotechnology. Furthermore, it is involved in a number of research activities and projects aiming at material innovations and material efficiency. With the development of measuring devices and procedures, the **Physikalisch-Technische Bundesanstalt (PTB, Federal Institute of Phyiscs and Metrology)**, the national metrology institute, is responsible for the standardization of metrology in Germany and ensures the traceability of measuring results to the International System of Units (SI). In the field of nanotechnology, the PTB is working on research projects regarding the quantitative characterization of nanoparticles as well as of nanoscale structures and is part of the respective standardization bodies. The **Federal Environment Agency (UBA)** deals with environmental and health-related aspects of nanotechnology. This includes both the consideration and evaluation of the environmental compatibility of nanotechnological applications and the possible risks for environment and health. The UBA initiates and supervises numerous research projects on ecotoxicology, on the behavior of nanomaterials in the environment and on the absorption and fate in the human body. The **Julius-Kühn-Institute (JKI)** deals with the issue of supporting agricultural innovations in the nanotechnological field through risk assessments. The **Johann-Heinrich-von-Thünen-Institute (vTI)** deals, inter alia, with nanostructured catalysts for the highly selective conversion of renewable raw materials into base and recyclable material for industrial purposes. Furthermore, the bonding and degradation of pollutants at bifunctional nanostructured materials is studied. The **Max Rubner-Institute (MRI)** works on nanomaterials in the food sector. Nanoscale carrier systems for bioactive substances and their behavior during food processing and under gastro-intestinal conditions are surveyed as well as the migration of nanoparticles from food contacting material, the influence of the particle size on the bioavailability and on the methods of acquisition as well as the characterization of nanoparticles in foodstuffs.

Commercial relevance – Corporate landscape

Germany is the leading nanotechnology nation in Europe and, comparing the commercial implementation worldwide, it is ranking third behind the USA and Japan. In Germany, about 950 enterprises [8] are dealing with the development and marketing of nanotechnological products, procedures and services on different stages of the value added chain – with tendency to rise. The percentage of innovative small and medium-sized enterprises (SME) and start-ups is around 80 %. More than 60.000 jobs in industry in Germany depend on nanotechnology. In 2007, the turnover in nanotechnology generated by Germany-based enterprises worldwide amounted to around 33 billion Euro [9].

German enterprises are manufacturers in the field of nanomaterials, nanotools, nanoanalytics and equipment for the operation of nanotools (e.g. vacuum and clean room technology, plasma sources etc.), manufacturers and users of nanooptimized components and systems as well as supplier of services in the field of consulting, contract coating, technology transfer, third-party analysis and research. Here, almost all important branches of industries are represented: optics, electronics, structural engineering, medicine/pharmaceutics, chemical industry, textile, mechanical engineering, security technology, environmental technology, biotechnology and consumer products.

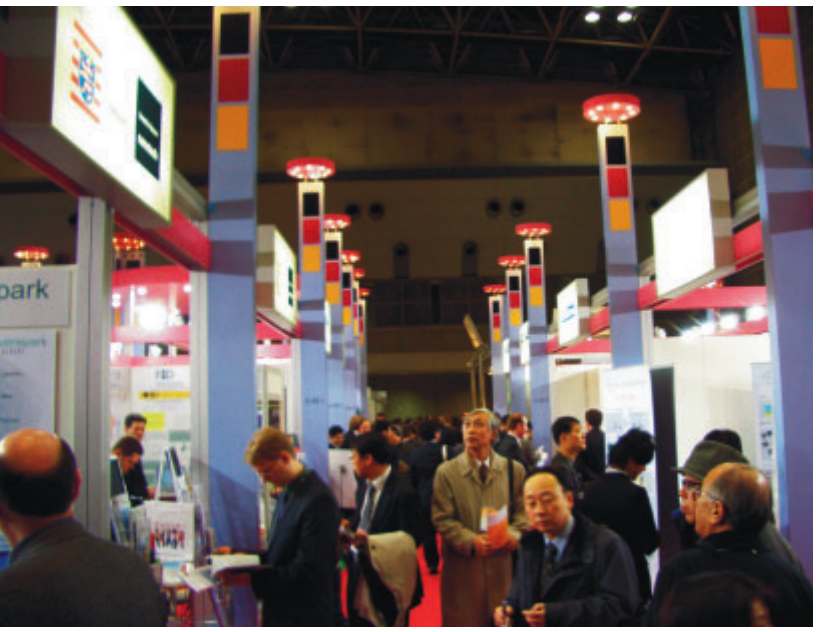
Usually, German enterprises are characterized by high export orientation. Therefore, cooperations are an important market element for most of the export-oriented companies. In this context, the European economic area is of utmost importance, followed by the North American and the Asian area. Germany is also internationally highly respected for its profound technological and infrastructural basis in nanotechnology. This turns German enterprises into interesting partners abroad, where in some cases the interest goes as far as to settle in local vicinity to the German competence centers.

Fabrication of optical elements for lithograhy devices

German nanotechnology – Research and development in international comparison

In the international comparison, Germany holds a strong position in nanotechnology. With Federal funding of about 400 million Euro in 2010, Germany ranked fourth behind the USA, Russia and Japan. Concerning scientific publications, Germany also ranks fourth behind the USA, China and Japan. In the comparison of international patents, the Organization for Economic Cooperation and Development (OECD) ranks Germany third behind the USA and Japan [10].

In Europe, Germany is not only leading with regard to funding, publications and patents in nanotechnology, but German partners were also very successful in the competition for European funds. Regarding the percentage of granted funds, German partners hold the top position in the 6th and the previous calls of the 7th EU-research framework programme. Here a comparatively strong participation of German industry in the projects is to be noted, which is always above the average value of the entire EU.



German joint exhibition stand at the Nanotech Fair in Tokyo

Nanotechnology – Political responsibility

Due to its versatile fields of application, nanotechnology is anchored in different departments of the Federal Government. This requires coordinated procedures within the Federal Government, which take into consideration the different aspects of nanotechnology from research over commercial utilization up to the protection of the consumer, the environment and the workplace, without resulting in doublings or unanswered questions being left. To ensure the coordination within the Federal Government, a cross-departmental committee was established, which ensures coordination and cooperation.

4 Supporting Research – Intensifying Knowlegde and Technology Transfer

4.1 Funding of Nanotechnology in Germany

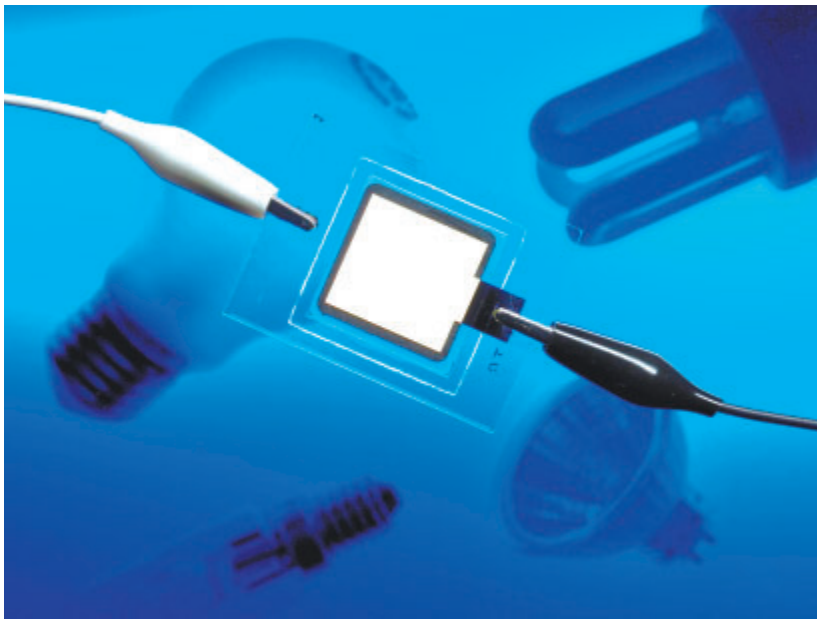
The organization of the funding activities with regard to content and strategy has undergone drastic change during the last 20 years. While the first nanotechnology-projects were clearly oriented towards the bases, in recent years the orientation changed towards application possibilities.

In the past, public funding investments in nano-technologies increased continuously all over the world and meanwhile amount to over 4 billion $ per year. Also the project funding means of the BMBF have increased more than tenfold since the beginning of the 1990s and amounted to around 200 million Euro in 2010. In Germany, the Federal funding means, provided for nanotechnological research and development, amounted to altogether about 400 million Euro in 2010.

In the years 2004 to 2006, private investments in nanotechnology were 2.3 billion Euro in Europe, i.e. about 33% of the total European investments, and 4.5 billion Euro in the USA, i.e. 54% of the total American investments. In Japan, 3.6 billion Euro and thus about 63% of Japan's total expenditure were invested in nanotechnological research and development [10].

The Federal Government will consolidate Germany's top position in the field of key technologies and therefore supports research, development and the transfer of know-how to commercial utilization. The focus is on the intensive cooperation of science and economy. The following instruments are intended to support that:

- **Collaborative projects** to network industry, in particular SME, with science, to enable access to facilities and know-how of high-technology research and thus to quickly transfer R&D-results into applications and products
- **Lead innovations,** strategically organized research cooperations, which are used to secure and expand established markets and to open up new growth fields.
- **Innovation alliances** as new instruments of research and innovation politics, which unite science, economy and politics in certain fields of application with high future market potential. With the strategically developed long-term perspective of the R&D-developments and the agreed allocation of work, time and finances, innovation alliances are meant to develop a decisive economic leverage effect.
- **Excellence clusters** specifically support strategic partnerships, where enterprises, scientific institutions and other regional actors jointly work on the market-relevant development of key technologies. Aim of the Leading Edge Cluster Competition is the consolidation and further expansion of Germany's position among the leading technology nations.



Illuminating element with flat organic light-emitting diode (OLED)

Innovation alliances in the field of nanotechnology:
Economy and science, together with the BMBF, have initiated five innovation alliances in the field of nanotechnology: Organic light-emitting diodes (OLED), organic photovoltaics (OPV), Inno.CNT, molecular imaging and lithium-ion batteries. With this, the right priorities were set. Example: climate protection and energy: The alliances contribute decisively to energy-efficient illumination (OLED), to the utilization of renewable energies (OPV) and to energy storage (lithium-ion batteries). In doing so, the innovation alliances develop a particular leverage effect: Within the framework of the OLED- and OPV-initiatives alone, almost one billion Euro have already been moved by economy, with 140 million Euro coming from the BMBF. Thus BMBF-funding lays the foundation to establish OLED and OPV production in Germany and to open up mass markets.

The **excellence cluster "Forum Organic Electronics"** pools the know-how of three DAX-companies, several world market leaders, two élite universities and numerous other partners from the Rhine-Neckar metropolitan region to lead Germany to the top of the world in the development of the future technology of Organic Electronics. Here, a new class of functional materials arises, which initially open up application markets in the field of photonics – illuminants and photovoltaics.

4.2 Global Challenges – Focus of Research Funding

Nanotechnology applications are expected to provide important solutions to the global challenges climate/energy, health/nutrition, mobility, security and communication described in the High-Tech Strategy of the Federal Government. Research funding in nanotechnology is thus oriented towards these topics. In this context, it is also because of the new BMBF framework programme on key technologies that nanotechnology is in a special focus.

4.2.1 Field of Action Climate/Energy

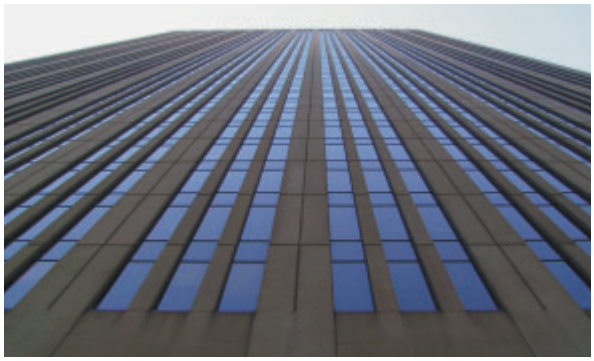
New orientation of energy supply, substitutes for dwindling resources and increasing demands on climate protection belong to the most urgent tasks of the future. Nanotechnologies provide great potential to establish industrial processes which require significantly less raw materials and energy at all levels of the value added chain. In the funding of nanotechnology, sustainability goals like the efficiency of energy and resources, securing of raw material cycles, maintaining environmental quality and climate protection are of high priority. Moreover, the aim is the overall reduction of the application of certain raw materials, e.g. rare metals like indium, and their long-term replacement. Within the framework of the planned research strategy on Bioeconomy, nanotechnological approaches can be applied for the utilization of biological resources.

Nanotechnology for higher energy efficiency – Actions

The research activities are aimed at the long-term increase in energy efficiency and support the measures of the energy research programme of the Federal Government.

- **Nanomaterials for adaptive building technology**
  The operation of buildings alone accounts for 40 % of the energy consumption in Germany. Thus higher energy efficiency of buildings contributes decisively to the achievement of the energy and climate-political aims. New, inter alia, high insulation and fireproof material both for cost-effective renovation of old buildings

and for new ones provide significantly improved thermal regulation. Nanomaterials are the keys for the development of thermochromic house paints, passive and active "Smart Glazing", micro-mirror arrays and switchable insulation materials or phase change materials as latent heat accumulator. Furthermore, the improvement of construction materials and their additives as well as the application of new construction possibilities provide high potentials.



- **Nanomaterials for decentralized energy supply**
  Renewable energy sources pose new challenges to energy suppliers: energy generation is not continuous. Thus measures are needed that reliably ensure the equal and demand-related feeding into the existing power grid. This requires inter alia robust and efficient energy storage, mainly in the field of electricity, but also in the field of heating and cooling. Nanotechnology allows, in particular, the development of new materials for the establishment of new storage systems.

Flexible Organic Photovoltaic Cells

Nanotechnologies for the adaption to climate changes – Actions

Already today, weather-related extreme events, such as flood disasters, periods of drought, heat waves and hurricanes account for more than 75 % of the natural disasters. It will certainly not be possible to simply redevelop these environmental changes, partly caused by humans, by ambitious climate protection. Under the heading of Adaptation, technological approaches are developed to adapt to extreme environmental conditions. Due to their unique material properties, nanomaterials can make a decisive contribution to that. Examples are filter materials or modified geotextiles which increase the water retention capacity in numerous applications, e.g. as preventive measure for the reinforcement of the dykes of lakes and rivers or in landscaping.

- **Development of filtering techniques:**
  Frequent and intensive heavy rains bear the risk of waters of different qualities to be mixed. Therefore improved filtering techniques are of growing importance. It has already become obvious that even here nanotechnology can improve services through catalytic processes. A second important field of application is the desalination of sea water.

- **Improvement of hygiene:**
  Increasing temperatures can cause or enhance hygienic problems. Filtering techniques can also be used to ensure hygienic requirements.

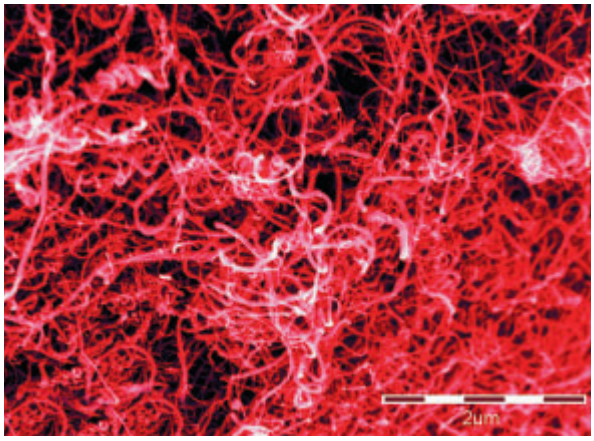
Protection of environment and resources – Actions

Within the framework of the High-Tech-Strategy, the Federal Government addresses the topical field of Protection of Environment and Resources as a part of the demand area Climate/Energy.

Nanotechnological developments can be related – in most different ways – to positive effects on the protection of environment and resources. This is where the funding of the Federal Government sets in:

- **NanoNature:** Nanotechnologies for environmental protection – **Benefits** and impacts
  With the NanoNature funding programme, nanotechnology-based technology developments in environmental protection are funded, such as procedures for water and air cleaning, soil rehabilitation and drinking water treatment. Further foci are procedures for product preparation, resource recovery and environmentally friendly separation processes as well as methods for the reduction of the discharge of substances into the environment through catalytic processes and separation processes.

- **Material efficiency, substitution of scarce raw materials and recycling**
  The substitution and the saving of scarce raw materials in widely used products, as e.g. (noble) metals in catalysts or electronic products by nanotechnologically influenced materials, is an important development objective. In particular, high-technology products depend on the availability of critical elements, which are mostly found in a few deposits partly situated in instable regions of the world. Thus the objective is to enhance material flows, to search for alternative substances and to save and efficiently use the resources. The application of nanotechnologies can contribute considerably to material efficiency through substitution of established materials. More material-efficient recycling at the end of the product life can occur in a non-destructive way by means of new joining technologies (e.g. nanobonding). In the chemical industry, new nanocatalysts can be the basis for alternative reaction paths, which save more energy at lower temperatures and allow optimal material usage due to their selectivity (low amounts of by-products). As environmentally friendly materials, completely new raw material sources, as for example new bioplastics, have the potential to replace conventional polymers or even metals, e.g. in car manufacturing. They are made of renewables and are not only characterized by an almost neutral CO_2 balance, but also lead to increasing independence from petroleum-based raw materials.



Agglomerate of carbon nanotubes (CNT)

- **Carbon nanomaterial – substitution and material efficiency**
  Carbo Nanotubes (CNT) play an increasingly important role in the development of new materials. Center of the German activities is the innovation alliance called “Carbon nanomaterials conquer markets – Inno.CNT“, which was started in 2008 [11]. Within the framework of this alliance, the basic research and application projects are combined with accompanying surveys on the impact of CNT on human health and environment. In future, the alliance will

address such objectives that will contribute decisively to the conservation of natural resources: As for example the substitution or the reduction of indium in indium tin oxide (ITO) for the production of transparent electrodes, e.g. in liquid crystal screens or organic light-emitting diodes, the use of conductive substances (e.g. conductive silver) or the utilization as catalyst (substitution of platinum or other catalyst metals) and the reinforcement of materials through CNT for lightweight-construction applications (reduction of material usage with same load capacity). This work, too, shall be accompanied by surveys on the impact of CNT on humans.

Reactor for CNT manufacturing

- **Low wear and environmentally friendly friction materials**
  The effect of many technical systems, as e.g. brakes, clutches, rollers, is based on the friction of non-lubricated contact surfaces. The optimization of the frictional contact resulted in the application of composite material with complex structures. Nanotechnological concepts in the design of such materials contribute to the improvement of desirable friction properties, such as braking effect und minimization of wear and tear. Apart from this, important goals in the development of environmentally friendly friction materials are better control of material components, the substitution of environmentally hazardous ingredients as well as concepts for the avoidance of nanoparticular emission.

Piston pin with adamantine coating for the reduction of friction in the motor

- **New materials for sustainable water management**
  Sustainable supply of drinking and industrial waters, the reduction of water pollution and the securing of water cycles belong to the global challenges of the 21st century. Technological solutions with material-specific approaches play a central role along the entire value added chain from water catchment, transport and distribution up to its disposal, purification and processing. Here, there is a great need for research in the development of efficient nanofiltration membranes as well as of new and environmentally friendly reagents and catalysts. Nanomaterials will also be increasingly applied in the field of adsorptive procedures.

Composite membrane with selective nanoparticles for water purification

- **Funding activity "Nano goes Production"**
  Concerning production technologies, nanotechnology will contribute to the reliable, economic and environmentally friendly production of more powerful and resource-efficient products. For this purpose, efficient industrial processes and equipment are developed along the entire value added chain, which enable the properties of nanoscale particles, fibers or layers and their interactions between themselves and with other materials to be controlled and adjusted. The focus is on the environmentally friendly, dust-free manufacturing of nanoscale particles, the processing of matrix materials and the coating of surfaces as well as on reliable online analysis.

- **New and safe components through multiscale simulation**
  New simulation strategies allow new insights into the structure of matter and the properties resulting from it. With multiscale simulation, it is possible to determine the electronic basic principles of the material behavior at an atomic level and the interaction of complex processes at the molecular level, in order to understand and forecast the behavior of components in use at the macroscopic level. Only the knowledge of the processes at the atomic and molecular level, i.e. at the nanotechnological level, creates the basis for the improvement of production processes and product properties. Thus multiscale simulation can considerably improve the understanding of highly dynamic interactions of the nanolevel with other system levels and can contribute to a quicker, more efficient and more target-oriented product development.

- **Survey on the potentials for the reduction of environmental pollution**
  The application of nanotechnologies promises the efficient use of raw materials and energy during the life cycle of a product and thus the reduced emission of pollutants or reduced energy consumption. For the survey on real potentials for the reduction of environmental pollution of concrete products, a generally adopted evaluation matrix shall be developed. This shall include the entire life cycle and shall analyze and evaluate existing innovation potentials of nanotechnological applications for sustainable development in the form of a systematically structured chance-risk consideration.

4.2.2 Field of Action Health/Nutrition and Agriculture

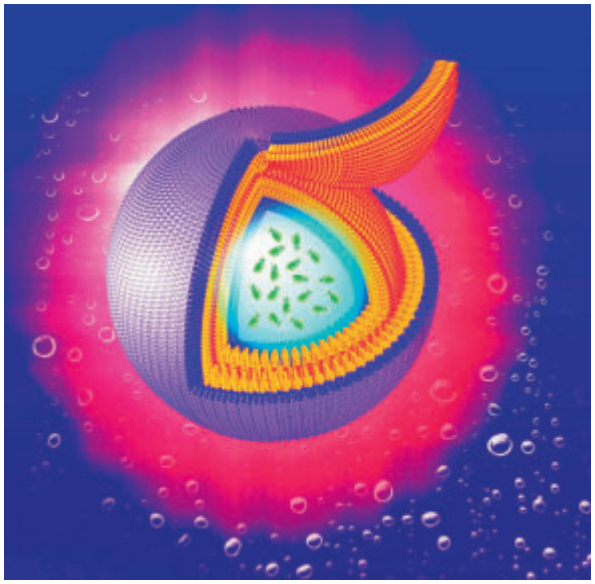
Health

The new possibilities of nanotechnology give important impulses for better diagnostics and treatment of diseases. Included in the funding measures of the Framework Programme "Health Research" of the Federal Government, new developments with the help of nanotechnological processes for diagnostics and therapy can be brought forward up to early clinical examination.

Actions

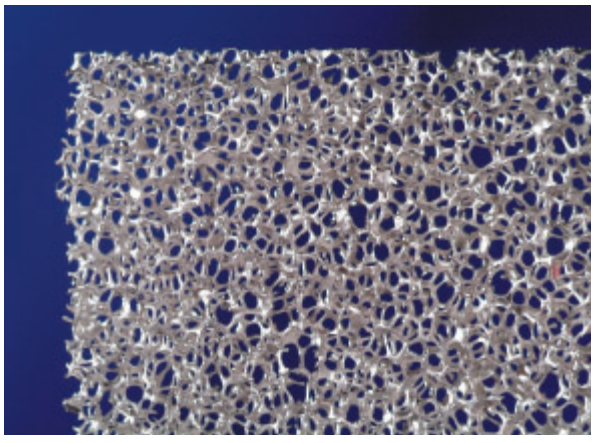
- **Molecular imaging**
  New diagnostic agents and imaging methods for clinics and the development of pharmaceuticals are the objectives of the innovation alliance on molecular imaging. The alliance aims at analysis of biological processes at molecular or cellular level to enable the detection of diseases at an early stage and/or more specifically and to improve diagnostics and facilitate specific therapies. Apart from the relevance of nanoparticles in the development of new contrast agents for molecular imaging, they can also be used as diagnostic sensors or for therapeutic purposes. Along general lines, integrated concepts of diagnostics and therapy, the so-called theranostics, are beginning to take shape. The Federal Government will thus strengthen research into molecular imaging and contribute to the early detection and specific treatment of diseases.

- **Tailor-made therapies and nanomedicine**
  Research into new (bio-) pharmaceutically active agents is intensively promoted all over the world. Being highly effective and highly specific, these substances are partly "tailored" to selected patient groups and, in the long run, set the trend towards personalized therapeutic products. In order to be able to fully exploit the potential of new active substances, new application systems (so-called drug-delivery systems) are required to enable the controlled transport of a sufficiently high dose of the active agent to a determined target site. The progresses in nanotechnology and materials technology will give important impulses for the development of improved injectors, inhalers and other applicator systems. An outstanding innovation field in this context is the combination of medical devices and medicines, as e.g. drug-coated vascular supports (stents). Here, nanotechnologies are in particular applied as coatings and matrices for the controlled release of active substances.



Molecularly structured nanocapsule for the embedding of active agents

- **Personalized implants and prostheses for long-term rehabilitation**
  Due to the demographic development, the focus of health research is more and more on age-related diseases. Implants are the backbone of the rehabilitative medicine for musculoskeletal diseases and to an increasing extent even for affected organ functions. In this field, nanotechnology can contribute decisively to the enhancement of the functionality of the implant and its compatibility when in contact with human tissue, since the interaction of implants with the biological surrounding takes place largely on the nanoscale.



Titanium-metal foam for bone implants

- **Regenerative medicine and nanostructured biomaterials**
  Innovative biomaterials and their processing can make a decisive contribution to the broad clinical application of regenerative medicine. So far, there are no suitable artificial three-dimensional carrier structures, which can adequately recreate the connective tissue structure of organs and ensure perfusion. This requires tailor-made nanostructured biomaterials and methods for their processing.

  Biotechnology is capable of providing biological replacement for damaged tissues and, in the distant future, probably for entire organs. In this context, future topics are the development of practically applicable cell culture systems, beside the generation of suitable cell material. Nanotechnologies and nanoprocess technology are urgently required for the progress in this field.

Nutrition and agriculture

Both agricultural economy and food industry can increasingly benefit from nanotechnology innovations, which are provided in the upstream fields (e.g. mechanical engineering, electronics, pharmacy). Within the framework of its departmental research (Federal Institute for Risk Assessment, Max-Rubner-Institute, and others), the Federal Government is also funding accompanying and safety research for the responsible application of nanotechnology in agriculture and nutrition.

Actions

Need for research emerges in the following fields:

- **Application of nanotechnology in plant protection for increase in efficiency, reduction of the amounts of active agents and improvement of the formulation of agrochemicals. Controlled carrier systems for the specific release of active agents for defined physical or chemical impacts (e.g. pH-value, UV-radiation, enzymes), impact assessment of nanomaterials for the controlled application in agriculture (risk assessment of the chemical, physical and ecotoxicological properties of active agents and carrier agents and of their discharge into the ecosystem as well as of the raw material flows)**
- **Application of nanotechnology for quicker, more cost-effective and precise diagnostic procedures in case of animal and plant diseases**
- **Analysis methods for the detection and quantification of nanoscale food ingredients**
- **Application of easy-to-clean nanocoated surfaces in food storage, transport and processing**
- **Application of nanotechnology for functional food packaging**
- **Application of nanotechnology for increased bioavailability of desired food ingredients**
- **Motor and gear development under consideration of high performance requirements in agriculture**
- **Development of novel concepts along the value added chain of Electric Power for the combination of energy generation from renewable energies with the utilization of electricity in agriculture.**

4.2.3 Field of Action Mobility

In the past, nanotechnology has already made important contributions to safety, sustainability and comfort in the automobile sector. The current central field of application of nanotechnology in the mobility sector is electric mobility. With the “National Electromobility Development Plan” and

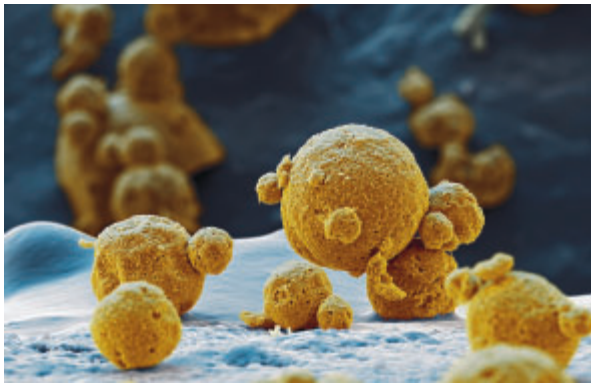
the 500 million Euro funding programme within the framework of the Second Economic Stimulus Programme, the Federal Government has laid the track towards modern sustainable mobility. Within the context of the National Platform for Electric Mobility, established on May 3rd 2010, a reliable strategy from basic research to market launch shall be developed and advanced in concentrated cooperation of politics, industry and science, local authorities and consumers. The basis for this is the "National Electromobility Development Plan". Furthermore, the "Federal Government Joint Unit for Electric Mobility" has established the "Joint Agency for Electric Mobility" (GGEMO). In order to achieve the aim of turning Germany into a lead market for electric mobility by 2010, today investments in research and development, thus also in nanotechnology, are required. This is the only way to create marketable components and systems as well as the related infrastructure.

Infrastructure for the electric-mobile future

Actions

- **Nanotechnology for cost-effective and resource-saving mobility**
  Due to its wide range of application possibilities, nanotechnology can contribute decisively to cost reduction, it can increase the reliability of technical components and improve the environmental compatibility in the mobility sector. Nanotechnology leads to innovations in the field of energy efficiency and in the fields of safety and comfort. Nanotechnology filters and cleans exhaust gases, increases catalytic surfaces with a minimum consumption of noble metals and, used in injection systems and as coating of cylinder runnings, it provides more efficient engines. In order to keep up with international competition, the full range of functions of a modern motor vehicle needs to be provided in a more cost-effective and more resource-saving way.

- **Nanotechnology for electric mobility**
  Efficient energy storage is the core of electric mobility. Nanotechnology and nanomaterials make important technological contributions to overcome currently existing hurdles.
  There is a great need for research in battery technology and grid integration for electric vehicles as well as for machinery and devices. New applications of nanotechnology are to be found, in particular, in the field of electrode and conductor materials with the aim of increasing the energy density, reducing the loading time and maximizing reliability and lifetime. And last but not least, nanotechnology shall help the battery cell to meet the very high quality standards in mass production with regard to function and regularity. Moreover, nanomaterials are important for super-capacitors as will be applied in hybrid and electric vehicles in future. Nanotechnology can also path the way for the application of fuel-cell driven vehicles, in particular through the development of efficient storage methods for hydrogen used as fuel.



Metal oxide particles for safe Li-ion batteries

- **Nanomaterials for intelligent streets**
  Efficient modes of transport and the respective transport infrastructure are of great importance for an integrated and sustainable transport policy. This includes the development of innovative technologies and materials for the preservation, renovation and new construction of traffic routes and facilities, such as streets, bridges and railway lines. Against the backdrop of economically realistic conditions, nanomaterials are intended to provide streets and other traffic infrastructures with new functions.
  This comprises, for example, noise-reducing

properties or the integration of sensor systems for road-to-car communication.

Prepared substructure for a concrete road surface

4.2.4 Field of Action Communication

In physics, new quantum physical effects are observed in the nanorange, which could be used to develop quantum computers. Quantum communication provides completely new and, due to basic physical principles, inherently absolutely secure access to the transfer of information.

Actions

- **Quantum communication as a basis for tap-proof communication**
  The Federal Government provides funding for research on the scientific foundations of quantum communication, which allows inherently secure data transfer in future telecommunication networks. In order to guarantee the transfer over long distances, the quantum information needs to be reprocessed after a certain transfer distance to further enable the reliable transfer. This step requires the development of a completely new component, the so-called quantum repeater. For the implementation of this component, nanotechnologically controlled systems such as atoms, ions or semiconductor structures shall be used. Special emphasis shall be put on the use of new materials with promising coherence properties, as for example, graphene or color centers in diamond.

Colored OLEDs for display and illumination applications

- **Organic or printable electronics**
  It is no longer the inflexible and expensive base material silicon, which is to be photolithographically processed, that forms the basis for this new sustainable electronics, but organic molecules or nanoparticular systems, which are easy and cost-efficient to print or to deposit. This permits extensive applications, e.g. illuminations, displays based on organic light-emitting diodes or organic photovoltaic modules, but also those on randomly formed or flexible substrates. Nanotechnology plays an outstanding role in printed electronics from several points of view. Extensive applications like organic light-emitting diodes or photovoltaics are based on the precise deposition of nanometer-thick multiple layers. Furthermore, the printing of organic molecules or nanoparticles requires new concepts for tailor-made pastes, inks and other printing formulations.

4.2.5 Field of Action Security

The protection of citizens against manifold threats like natural disasters, major technical incidents, but also against globally increasing terrorism is an important objective of the Federal Government. With the global networking of terrorist and criminal activities and the increase in civil security requirements, e.g. for the securing of international transport and supply chains, increased demand for technological security products emerges. This also reveals the increased societal need for security.

Apart from the protection against dangers and the creation of secure conditions regarding the location, security-related products and services also provide opportunities for the economy. According to a survey on behalf of the Federal Ministry of Economics and Technology, the market volume for security-related products and services in Germany amounted to about 20 billion Euro [12] in 2008 alone. The growth and value creation potential for German enterprises on the world market is promising. Since the realization of a competitive edge is a prerequisite for the effectiveness of security measures and products, nanotechnology in the field of nanoscale functional materials can make a contribution to the improvement of future security applications.

Actions

- **Document protection and product security through product identification and marking systems for the generation of optical security features**
  The major driving force in the field of document security and product protection are, in particular, the damages in trade caused by product piracy and counterfeiting, which amount to estimated 600 billion worldwide each year. The spectrum of product counterfeiting reaches from high-quality consumer goods over security documents and currencies up to pharmaceutical products or spare parts for cars and aircrafts. Therefore, a number of product identification and marking systems have been developed, which are based on the use of nanotechnological or nanobiotechnological materials, such as fluorescent nanoparticles or nanoscale structuring processes, and which are used for the generation of optical security features. Furthermore, suitable are also biological materials, as used in form of security inks for copy protection and against counterfeiting of security documents.

- **Development of nanotechnological materials for the managing of potential consequences of major incidents**
  Decontamination and filtering technologies for the protection of critical infrastructures and technical plants belong to the promising fields of application with market potential. There are numerous new challenges, in particular in the field of civil defense and disaster control, as for example in the managing of potential consequences of the release of chemical, biological or nuclear hazardous substances after terrorist attacks or large-scale accidents. Based on existing procedures of chemical nanotechnology, which enable the production of self-cleaning nanostructured surfaces and the integration of catalytically active nanoparticles in tailor-made multifunctional coating systems, improved decontaminating technologies with higher long-term stability and a broader application spectrum are being developed. This enables, inter alia, the degradation of chemical hazardous substances and/or the inactivation of biological agents.

- **Development of stab and bullet-proof nanoscale materials for protection systems for policemen and rescue workers**
  A likewise promising field for security-related applications is the development of integrated protection systems for the protection of policemen and rescue workers against hazardous substances, explosion impacts, fires and projectiles. Here, the focus is on the development of stab- and bullet-proof textiles, for example of polymer nanocomposites. In this context, approaches regarding the material are seen in the use of particularly shock-proof CNT-fibers with high tensile strength or so-called dilatant or shear-thickening nanofluids in protection vests as well as in the development of clothes resistant to chemicals or heat with self-healing properties.

5 Securing the Competitiveness of Germany as an Economic Location

Industry, as the driver of innovation, contributes much to growth and employment. Regarding the contribution to the overall economic value, in Germany industry is traditionally more important than in other big western industrial nations. In globalized markets, industrial production is more and more the result of international value added chains. In order for German markets to hold their own in the competition for this added value, research-intensive products are indispensible. Even though German processing industries are characterized by a particularly high proportion of knowledge-intensive products, they must continuously prove their competitiveness through innovations. Key technologies, such as nanotechnology, can give decisive impetus to the development of such innovative products and processes.

5.1 Creation of Value Added Chains – Germany as Production Location

The German corporate landscape in nanotechnology is already broadly positioned. This applies to its topical orientation as well as to the positioning within the value added chain. Therefore, the accelerated transfer of research results into commercial practice requires the strong orientation of research funding towards the industry-specific problems and demands.

Actions

- **Branch-level industry dialogues**
  In the past, industry-specific funding activities of the Federal Government contributed to the fact that the potentials of nanotechnology were not only tapped in the field of high technology, but also in the traditional branches of industry, such as the building sector or the textile industry. These measures were prepared by industry dialogues addressing in particular SME in the respective branches of industry.

  The future focus of the dialogues shall be on the application of nanotechnology for the fields of action of the High-Tech Strategy. In this context, the fields of environment and energy shall be the first to be addressed. Apart from the technological issues, also factors like scalability, adaptation to existing technology solutions, price, service capability as well as solutions within the scope of the existing regulations play a special role. These industry dialogues are carried out in close cooperation with industrial associations, innovation clusters on state-level as well as regional business developers such as chambers of industry and commerce.

Industry dialogue addressing value added chains

5.2 SME-Funding

Not only do SME account for about 70 % of all working places in industry in Germany, they are also pioneers of technological progress in many fields. About 80 % of the nanotechnology enterprises are SME and start-up companies; 70 % were established only after 1985 [9]. As suppliers of nanooptimized components, tailor-made system solutions or services, they are an important link between applied sciences and product and/or application development. Against the backdrop of intensifying international competition, however the risks and financial expenditures related to cutting-edge research are often difficult to shoulder by SME. The Federal Government supports the commitment of innovative SME in the field of nanotechnology through specific measures of the SME-funding to simplify their way from potential-promising technological developments up to the successful commercial marketing. For this purpose, specific activities for nanotechnology enterprises were initiated. Moreover, non-technology specific measures address medium-sized enterprises active in nanotechnology.

Nanotechnology-specific actions

- **KMU-Innovativ Nanotechnology – NanoChance**
  The funding activity, specifically aimed at SME, is intended to open up the innovation potentials of SME in the field of nanotechnology and to support the establishment of SME in the market for nanotechnologies. In order to facilitate the participation of SME in the funding programme, the BMBF has simplified and accelerated the application and approval process, in particular for SME which apply for the first time, and has extended its consulting services. KMU-Innovativ Nanotechnology is intended to strengthen the industrial basis in the field of nanotechnology [13].

Non-technology specific actions

- **Zentrales Innovationsprogramm Mittelstand (ZIM)**
  ZIM offers small and medium-sized enterprises support for their innovation activities. The funding programme, particularly tailor-made to the requirements of SMEs, is aimed at the improvement of the competitiveness of enterprises. Within the framework of individual and cooperation projects, research and development are funded with the aim of new technological products and improved processes. In this context, knowledge transfer between science and enterprises is an important element. Furthermore, ZIM also supports the creation and management of networks of innovative SMEs. Nanotechnology plays an increasing role in the non-technology specific and non-industry specific ZIM [14].

- **Collective research (IGF)**
  In its collective research programme (*Industrielle Gemeinschaftsforschung*, or IGF), the Federal Ministry of Economics and Technology supports relevant research projects for the broader benefit of small and medium-sized companies. In coordination with participating companies, research associations propose joint projects within the framework of a competition; expert opinions then determine which projects will be selected for implementation. The results of these projects are then placed at the disposal of all interested companies under equal conditions. Currently, 69 ongoing IGF research projects (and since 2006, a total of 132 projects) focus on the topic of nanotechnology – this represents six percent of all IGF projects. In order to foster the rapid and widespread penetration and dissemination of research findings throughout the research landscape, the research associations work together within the framework of a research network. In this way, the collective research programme makes a key contribution toward ensuring that businesses – particularly small and medium-sized companies – gain access and use rights to research findings in the field of nanotechnology.

- **EUREKA-Programme Eurostars**
  The entry into the international cooperation in research and development and the access to international markets shall be facilitated by the European Eurostars Programme, the Federal Government is involved in via the Ministry of Education and Research (BMBF).

5.3 Start-up Funding and Start-up Conditions

Young knowledge-based enterprises close the innovation gap between academic research and industrial application. They are of great importance, in particular in research-intensive nanotechnology enterprises. Sufficient funding is an indispensible prerequisite; financing restrictions

belong to the highest hurdles in the innovation process. Therefore, the Federal Government has taken a bundle of measures to encourage start-up and growth dynamics of innovative young entrepreneurs in Germany. The activities are not bound to a certain technology however they are all related to nanotechnology.

Actions

- **Validation of research results**
  Validation funding [15] is intended to support scientists from academic research and to verify their research results with regard to technical feasibility, the opening up of new application fields and their commercial potentials at an early stage. This bridge between academic research and commercial application provides the prerequisite for successful further development to innovative technology-based products, processes or services. Following the validation project, all other ways of utilization besides starting up a business are open.

- **High-Tech Gründerfonds**
  The High-Tech Gründerfonds (HTGF) invests venture capital into young, promising technology enterprises. It makes the urgently needed start-up capital available (equity capital in a first financing round of up to 500,000 Euro, altogether max. 1 million Euro per enterprise) and provides the necessary assistance and support for the management in the early phase of corporate development [16]. The grants are distributed across all Federal States and fields of innovation, among them high-tech start-ups of nanotechnology in the fields of medicine technology, chemistry and biotechnology.

- **EXIST – Business start-ups from science**
  With the funding programme "EXIST – Business Start-up From Science" [17], already initiated in 1998, the Federal Ministry of Economics and Technology supports measures to embed a culture of independent entrepreneurship and to boost the start-up activities at universities and in non-university research facilities and it funds innovative start-up projects from science:

- **EXIST-Start-up Grant**
  The EXIST-Start-up Grant supports founders from universities and non-university research institutions, who intend to transfer their start-up idea into a business plan, in the development of meaningful business plans and the preparation of the start-up of their innovative enterprise. Founders, also teams of two or three people, receive a grant for two years and material expenses as well as coaching means. About 5 % of them are related to nanotechnology.

- **EXIST-Research Transfer**
  Since November 2007, the EXIST-Research Transfer has been supplementing the EXIST-Start-up Grant, which has a rather broad-based impact. EXIST-Research Transfer facilitates the often only difficultly fundable way of technically particularly sophisticated start-up projects from laboratory to market. Each year, about 25 to 30 technologically particularly demanding spin-off projects from universities and non-university institutions are funded nationwide, which derive from completed research projects and which require considerable risky development work until they reach their "start-up maturity". As a cross-sectional technology, nanotechnology ties in with the fields of biotech, medicine technology, materials research and laser/optics. About 10 % of the founding projects funded by the EXIST-Research Transfer are dealing with nanotechnology.

Funding example: Particular GmbH, Hanover
The start-up enterprise Particular GmbH is the result of the spin-off from the Laser Zentrum Hannover e.V. (LZH) at the end of 2009, which has been involved in research and development projects on laser development and laser applications since 1986. Since 2004, the LZH has been developing processes for nanoparticle generation by means of laser ablation in liquids. Particular is the first company worldwide making laser ablation in liquids commercially available for the production of nanoparticles (particular.eu). The start-up of the Particular GmbH has been funded by the EXIST-Research Transfer from September 2008.

- **SIGNO – Protection of ideas for commercial utilization**
  The SIGNO funding programme supports universities, enterprises and inventors in obtaining legal protection and effecting the economic realization of their innovative ideas. It supports technology transfer through the efficient utilization of intellectual property [18].

- **Power to female founders**
  The initiative "Power to Female Founders" (Power für Gründerinnen) targets in particular at highly qualified women and is intended to facilitate their step into independence and the founding of innovative enterprises [19]. In the field of nanotechnology for example, Nano-Entrepreneurship-Academies (NEnA) are supported, which, as an initiative of the network nano4women, bridge the gap between science and economy and develop and award prizes to innovative business ideas and models [20].

Female participants of the NEnA-Entrepreneurship-Academy

- **Entrepreneurial Regions**
  The potential commercialization of research results plays an important role in the innovation initiative for the New Federal States. Within the framework of the programme called "Research for the Market in Teams [ForMaT]", researchers are supported in their project to systematically develop their commercialization approaches into business plans [21].

- **Joint Initiative for Research and Innovation**
  Within the framework of the Joint Initiative for Research and Innovation, research institutions have committed to increasingly address economy in order to improve the innovation balance through joint planning processes and research efforts as well as innovation partnerships and technology transfer. For this purpose, they shall also further expand the instruments for the funding of spin-offs from research institutions and for the utilization of research and development results in networks [22].

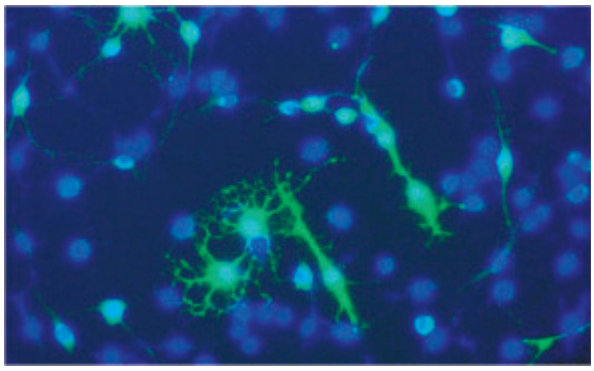
- **Business start-up culture and framework conditions**
  The initiative "Gründerland Deutschland" shall support a paradigm shift and a societal climate for entrepreneurial spirit and positive evaluation of independence [23]. In particular, young people at schools and universities shall be more sensitized to the opportunities of the step into independence. Founders shall also be given a second chance after an unsuccessful takeoff.

  Moreover, improved framework conditions are planned for venture and equity capital as well as for activities of the so-called "Business Angels", i.e. experienced entrepreneurs which assist start-ups with capital and advice. The Federal Government supports this with joint initiatives such as the "Business Angel Year 2010", which shall offensively promote the commitment in this field.

6 Identifying Risks of Nanotechnology – for Safe and Responsible Handling

Just like any other technology, also nanotechnology is related to possible impacts on and risks for humans and environment. The Federal Government is aware of this responsibility for the protection of humans and environment and consistently follows the strategy of exploiting the opportunities of nanotechnology for the society and Germany as a location. At the same time it supports a development of nanotechnology which is sustainable and compatible with environment and health.

Results of the NanoCare, INOS und TRACER projects [24] indicate that size in the nanometer-scale of materials alone is no basis for the risk assessment. In fact, nanomaterials can show different toxicological potentials depending on parameters like structure, morphology, chemical composition and concentration. Thus potential risks must be studied on a case-to-case basis and the result must be verified by long-term studies.



Examination of cell behavior in presence of nanoparticles

The Federal Government will control and adjust the effectiveness of risk prevention and management measures in a continuous technology-accompanying process. However, the worldwide safe handling of nanotechnology will only be achieved by internationally harmonized product and safety standards based on recognized measuring and analysis techniques. For this purpose, the Federal Government is funding numerous initiatives aimed at international coordination.

Nanomaterials are also increasingly included in consumer-oriented products. Consequently, staff, consumers and environment might be exposed to them. At the same time, basic knowledge about the risks related to this exposition is often lacking. Therefore, the Federal Institute for Occupational Safety and Health (BAuA), the Federal Environment Agency (UBA) and the Federal Institute for Risk Assessment (BfR) published a joint research strategy on nanotechnology in 2007 [25], in which the Federal Institute for Materials Research (BAM) and the Federal Institute of Physics and Metrology (PTB) are involved as well. With the aim of prioritization and coordination, topics were identified which are equally important for occupational safety, consumer protection and environmental protection, but also topics which are of great importance for individual fields only. A first conclusion will be drawn in 2011 and based on this, the strategies will be continued and foci will be set on research topics of subsequent years.

6.1 Health Protection/Consumer Protection/ Food Safety

With the wide diffusion of nanotechnology-based products, such as cosmetics, cleaning agents and household articles, consumer protection and food safety are gaining more and more importance. As yet, there are no legal regulations on the information about the use of nanomaterials in products and their indication is generally subject to the decision of the product manufacturer. In application fields, for which approval procedures are planned, the relevant information will be available within the scope of the respective approval application. As of 2013, the marking of nanoscale components in cosmetics on the basis of the Regulation (EC) No. 223/2009 will also be obligatory in Europe.

Food

According to available information, the use of specifically manufactured substances with nanoparticular dimensions for foodstuff is currently not relevant in Germany. Nevertheless in future, opportunities to confer certain properties to food by using ingredients in nano-size could arise. Doubtlessly, such substances may only be used in foodstuffs if they do not entail risks for the consumer. Foodstuffs must generally be safe. In order to sufficiently guarantee this, the required foundations were laid or are planned by adapting the relevant legal regulations.

In 2009, the European Food Safety Authority (EFSA) has published a statement regarding the evaluation of nanomaterials in foodstuffs. The EFSA Scientific Committee came to the view that the proven international approaches for risk assessment can also be applied to engineered nanomaterials (ENM) [26]. They drew the conclusion that a case-by-case approach is required.

Food contact materials

In the field of food contact materials, there are already various products on the market, which were manufactured by using nanotechnology or which contain nanomaterials. These include packaging with barrier effect and/or with coatings serving as barriers against humidity, oxygen or UV-light, packaging materials with antibacterial features or with indicator functions to detect and display spoiled foodstuffs. Furthermore, nanomaterials can be used for the functionalization of surfaces as process materials in food production (e.g. conveyor belts) where they can achieve certain effects, as inter alia, cleanability ("Lotus-Effect"), energy efficiency, adhesion properties. In implementation of the Community law, the Federal Government has recently approved the market authorization of a nanomaterial for the use in plastic food contact materials. The approval concerns a nanoparticular titanium nitride for the increase of product efficiency in the forming of plastic materials and it is limited to the use in PET-bottles in concentrations of up to 20 milligram per kilogram. According to the European Food Safety Authority (EFSA), there is no health risk under these particular conditions of use, since the migration into foodstuffs and thus a risk for consumers is not to be expected [27].

Cosmetic substances

Nanoparticles in cosmetic substances are often present in agglomerated form. Penetration into and/or absorption through the skin is thus unlikely. As long as it is guaranteed that these products are used on healthy skin and on the assumption of exclusively dermal exposition to nanoparticles with a size of over > 20 nanometers, there are no signs of direct risks for consumers so far [28].

Drugs and medical products

Drugs may only be used when their safety for the patients is tested and confirmed. In the case of drugs, this evaluation occurs within the framework of the official approval procedure, and in case of medical products through the conformity assessment procedure. The same applies to products covered by the generic term "nanomedicine". On EU- and international level, strategies for the further development of the risk assessment for nanomedicine-products are currently being discussed.

Actions

- **Alignment of relevant legislation** to the specific concerns of nanotechnology, if required (e.g. in the field of novel food).

- **Scientifically substantiated risk assessment**
  Within the portfolio of BMELV, the Federal Institute for Risk Assessment deals with the scientifically substantiated risk assessment of the use of nanotechnology in consumer-oriented products, cosmetics, foodstuffs and food contact materials (e.g. packaging). For this purpose, numerous research projects will be carried out and/or commissioned, expert surveys will be held and current studies will be compiled [29].

- **Accompanying and safety research on nanotechnology in the agricultural and nutritional sector.**
  The Federal Institute for Risk Assessment, the Max-Rubner-Institute, the Federal Research Institute for Nutrition and Food as well as other research institutions provide accompanying and safety research on nanotechnology in the agricultural and food sector. For the coordination of their activities, they have established a senate working group for “Synthetic Nanomaterials”.

- **Development of the analytics of nanoparticles in complex matrices.**
  The Federal Institute for Risk Assessment and the Max-Rubner-Institute invest considerable physical resources and human resource capacities in the development of nanoanalytics in the food matrices.

- **Safety research in cosmetic substances**
  The results available so far lead to the conclusion that nanoparticles used in cosmetic substances should be examined at least with regard to their size distribution on the skin and in the stratum corneum. Measuring methods for the detection of particles in the formulations and on the skin must be developed.

6.2 Impacts on Humans

Despite comprehensive research work on the impacts of nanomaterials on humans and environment on a national and international level, there are still significant knowledge gaps that require to be closed. Extensive measures have been initiated in this regard; however, risk research shall also be expanded in future. Here, works on toxicological effects of nanomaterials as well as the analysis of possible exposition scenarios over the entire life cycle for relevant application fields of nanotechnology are in the focus. So some nanomaterials can pass biological barriers earlier than larger particles do and can thus reach parts of the organism which are not accessible to coarser particles. In order to develop materials which do not show these properties, a comprehensive assessment of the impacts is required.

Actions

- **Toxicological risk characterization of nanomaterials**
  Due to the increasing number of different synthetic nanomaterials, it is important to deduce not only the individual material but also active principles for toxicological characterization. The issues of genotoxicity, carcinogenicity, the disintegration of agglomerates and aggregates in the target organ and of the impact of deliberately modified surface properties are in the foreground.

- **NanoCare – Impacts of synthetic nanomaterials on humans**
  The focus of the NanoCare funding activity is the systematic research of human- toxicological effects and interactions of synthetic nanomaterials on humans, issues of exposition, the development of measuring strategies and test systems as well as the proof and the evaluation of possible toxic effects on humans along the life cycle of nanomaterials.

Measuring of the particle number concentration in the processing of nanomaterials

- **Nanomaterials of anthropogenic origin in the environment – impacts on humans**
  It has not been surveyed so far whether and to which extent nanomaterials of anthropogenic origin can reach foodstuffs unintentionally through contaminated soil, water and air. Therefore, an evaluation of possible sources of unwanted introduction of nanomaterials shall be carried out. For this purpose, analysis techniques and methods need to be further developed.

  The exposure of humans to nanomaterials existing in the environment is also possible indoors, if nanoparticles are increasingly used in consumer-oriented products and products which are applied indoors. Future research projects will deal with the further development of analysis methods, with the detection of effects of the nanomaterials deposited in the body as well as with the consumption and distribution of different kinds of nanomaterials.

- **Performance of long-term studies on the impacts on health**
  Most of the studies performed so far are based on cellular studies and short-term tests. In order to enable the long-term observation of the accumulation of nanomaterials in cells and tissues, long-term studies shall be carried out in future to form the basis of risk assessment.

6.3 Occupational Safety

The safe handling of nanomaterials at the workplace is a central demand, in particular made by manufacturers and users. In the field of safety and health of employees, the BAuA has set the focus on the exposure at the workplace, toxicological risk characterization and contributions to the prevention strategy.

Actions

- **Workplace exposure in case of activities involving nanomaterials**
  The reliable detection of the exposure of employees to nanomaterials requires suitable measuring processes and strategies. In this context, important topics are the acquisition of experimental knowledge about the exposition of employees, the validation and standardization, the material differentiation and distinction from background exposure, adequate filtering technology, personalized sampling as well as the characterization of the dust emission behavior of nanomaterials.

- **Contributions to the prevention strategy for nanomaterials at work**
  Pending the rectification of the deficits regarding the evaluation of health risks at the workplace caused by nanomaterials, strict occupational safety measures as defined by the precautionary principle are taken, which will be gradually adapted to the actual health risks according to the increasing gain of scientific knowledge. In this process, the BAuA supports the regulatory actions with expertise, projects and guidelines on legal and sublegal level as well as the self-responsibility of enterprises in the field of nanotechnology.

- **Advising enterprises on the handling of nanomaterials with regard to occupational safety**
  Nanotechnological materials innovations shall be accompanied by safety research and advice which sets in already at the threshold from laboratory stage to pilot production/application technology. Due to the high tonnage threshold and the limited test programme, the requirements of the REACH-regulation [30] take effect late, in particular for SME and start-up enterprises, to accommodate their important desire for user-safe products at an early stage – also an important aspect from a liability point of view. For this purpose, the BAuA provides advice and support in measuring the emission of nanoparticles.

6.4 Impacts on the Environment

Research initiatives on possible environmental risks caused by nanomaterials skyrocketed over the past years. Nevertheless, there are still knowledge gaps in the environmental sector. Focus of the initiatives is the simultaneous analysis of benefits and risks for the environmental sector and, in particular, the issue of sustainability. Here, it is necessary to include the entire product lifecycle and the disposal paths, as e.g. wastewater, and to adapt the existing methods (e.g. standardized tests for the recording of the ecotoxic effects according to ISO (International Organization for Standardization) or OECD (Organization for Economic Co-Operation and Development)) to research into nanomaterials. In this context, the production of reference materials and the preparation of stable test suspensions are particularly difficult.

In-situ remediation with nanoscale iron particles

Actions

- **NanoNature** – Nanotechnologies for environmental protection – Benefits and **impacts**
  Apart from the analysis of structure-effect relationships, mechanisms of action and relevant effect thresholds, the range of tasks also includes the development of adequate measuring and test methods for risk assessment. Further foci are the issues regarding the mobility of nanoparticles, the interaction with other substances in environmental media or their bioaccumulation along the food chain.

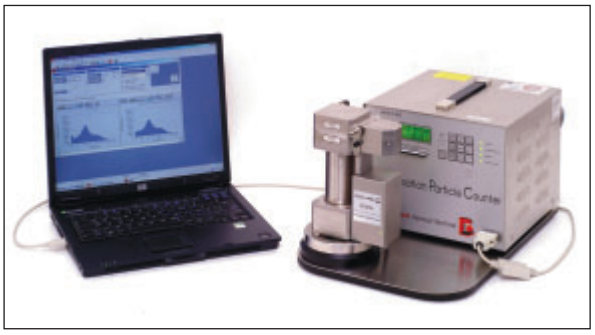
Laboratory tests on the application of nanoparticles

- **Grouping of nanomaterials on the basis of their environmental behavior**
  In order to describe behavior and fate of nanomaterials in the environment, the relevant factors need to be identified. Apart from particle size and distribution, form and morphological surface structure, this may also include factors such as agglomeration, sorption, interactions with other chemicals in the environment, catalytic activities or carrier functions.

- **Development of test methods for safety evaluation**
  Standardized tests to determine possible safety risks have been developed for the testing of "classical" chemicals, and thus for soluble or poorly soluble substances. These methods need to be examined and if necessary adapted regarding their suitability for the examination of nanomaterials. The results shall, inter alia, also be included in the steering committee 4 "Manufactured Nanomaterials and Test Guidelines" of the OECD "Working Party on Manufactured Nanomaterials (WPMN)" [31].

- **Research on the exposure of the environment to nanomaterials**
  Currently, a comprehensive evaluation of emissions and the exposure of environmental media to nanomaterials are possible to a limited extent only. Measuring methods and quantitative data on the emission of nanomaterials from products in use and after their disposal are only occasionally available so far. Furthermore, possible mechanisms and probabilities for the release of nanoparticles from composite materials must be researched and/or assessed. The evaluation of emissions and exposure must cover the entire lifecycle. There is great demand for research in the field of exposure protection, e.g. on filters, and regarding the disposal of products containing nanomaterials after their period of use. In this context, guidelines for proper disposal must probably be developed.

- **Long-term studies on impacts on the environment**
  Studies regarding the effects after long-term exposure are required. This necessitates the development of protocols and the determination of technical standards for the description of materials during the ecotoxicological test. Some of the projects funded within the framework of the Environmental Research Plan are already dealing with the possible necessary adaptations of the OECD-Directive on the ecotoxicological survey of synthetic nanomaterials.



Sequential mobility particle counter

- **Development of measuring methods for the determination of nanomaterials in environmental compartments**
  The determination of nanomaterials in the environmental compartments water, soil and sediment as well as in the organisms living therein requires the development of adequate measuring methods. When measuring entry, fate and behavior of nanomaterials in the environment, the specific properties of the nanomaterials, the interaction with environmental media and chemicals as well as a naturally occurring background concentration can complicate the determination of nanomaterials. In this case, existing test methods must be adapted and, if required, new methods need to be developed.

- **Green nanotechnology**
  Main research areas for the sustainable securing of global livelihood in the fields of climate protection, nutrition and water supply as well as the substitution of scarce resources within the meaning of "green technology" will be further expanded in the next five years. Based on lifecycle analyses, on mass and energy flows as well as on safety aspects across the entire product cycle, the impacts of nanotechnological developments are evaluated and weighed up against alternative options. Moreover, the sustainable and lower-risk design of nanomaterials and products themselves are in the focus, so that the technological nanofunctionality will be fulfilled without having adverse effects on the sustainability goals.

6.5 Ethical and societal issues of nanotechnology

For some years, there have been discussions in the field of nanotechnology about possible impacts, risks and preventive measures as well as about the regulation. The dealing with this problem requires the objective discussion and the responsible assessment of chances and risks for the individual and for society. Moreover, generally ethical and societal issues are discussed in nanotechnology. This includes e.g. data protection and privacy issues in light of more effective methods of sensor-based monitoring as well as the detection and storage of medical data. Also, bioethical aspects play a role in the field of nanotechnology, for example in connection with the interference with the human organism for the purpose of performance enhancement, with individualized medicine and with questions on the man-machine relationship and on the image of humanity. It is of decisive importance that these issues are scientifically reflected in a critical way and discussed in public to enable the development of solutions. One must bring to mind that both the risk issues and the ethical aspects in the context with the respective fields of application require consid-eration and/or evaluation. Neither the technology used for a certain application nor the scale of this technology can represent a reasonable criterion for the delimitation of the technology field on a general basis.

The focus of social sciences and humanities is also on research into the interrelation of societal conditions for innovations and the effects of innovations on society. This is also true for nanotechnology. Thus the reflection of the interaction between nature, technology, society and culture by means of socio-scientific, economic and humanistic research is necessary to determine the socio-cultural preconditions for technical and social innovations. This way, the realization chances for a broad implementation can be increased and the impacts of technical innovation on culture and society can be assessed at an early stage.

Actions

Since 1998, the BMBF has been funding research into ethical, legal and social aspects (ELSA, Ethical Legal and Social Aspects) in life sciences as an integral part of research. Within the scope of this funding priority, essential life-science developments and their implications are critically and early reflected in interdisciplinary cooperation.

Furthermore, the BMBF is currently funding projects in socio-ecological research, economics for sustainability and in scientific research, which deal with these interrelations.

7 Improving Framework Conditions

7.1 Legal Framework Conditions

The Federal Government will develop nanotechnology in a responsible way. From a regulatory point of view, it will be vital to adequately control the risks potentially arising from nanotechnology and, at the same time, to use the societal and economic potentials.

Law on chemicals

Apart from the sectoral provisions for cosmetics and food, the European law on chemicals, in particular the European Directives REACH (Registration of Chemicals) and CLP (Classification and Labeling of Chemicals) [32], is currently the most important framework for the legislative handling of nanomaterials. The Federal Government assumes that the REACH-provisions are basically well suited to cover nanospecific properties of chemicals. With its European partners, the Government is discussing a comprehensive concept of how to regulate nanomaterials under consideration of the precautionary principle. A sub-working group of CARACAL (Competent Authorities for REACH and CLP), the CASG Nano (Competent Authorities Subgroup Nano), establishes recommendations for the treatment of nanomaterials in REACH. They refer to amendments in the provisions, in particular to the definition of nanomaterials and the addition of specific standard test programmes. With these adaptations and the risk-assessment instruments already provided by REACH, nanotechnology can meet the requirements of occupational, environmental and consumer protection.

Food

Just as to other foodstuffs, the general food legislation, in particular the Directive (EC) No. 178/2002, as well as the German Food and Feed Code (LFGB) apply to food that contains nanoparticulate ingredients. Accordingly, only safe food may be released on the market. Furthermore, depending on the kind of food/food ingredient, specific regulations are relevant:

a) Food additives
With a view to the potential application of nanoparticles in the food sector, great emphasis was also placed on the topic of nanotechnology in the revision of the EU-regulations on food additives. The Regulation (EC) No. 1333/2008 provides for a re-evaluation of safety and, if necessary, for the new approval of food additives, which shall not be used in the conventional, already tested form, but e.g. in nanoscale dimensions.

b) Novel food
In case nanoparticulate ingredients are applied in food for other than technological purposes, e.g. for nutritional reasons, the Directive (EC) No. 258/97 on novel food and novel food ingredients will apply under certain conditions. Thus, they are subject to the approval procedure set out in the Directive (EC) No. 258/97, which includes a comprehensive safety assessment.

The regulations on novel food are presently revised on EU-level. According to the current state of negotiations, provisions for further regulations on nanotechnology are made in addition to the already existing law. Accordingly, food which contains engineered nanomaterials or which consists of those, shall generally be covered under the scope of the regulation on novel food and thus under the approval and assessment procedures stipulated therein, regardless of whether or not a significant change in the foodstuff was caused. As before, specific labeling requirements can be defined within the framework of the approval. The consultations on the new regulation are not yet concluded. A publication is to be expected in the year 2011.

Food contact material

Food contact material must fulfill the general protection provisions of the Regulation (EC) No.1935/2004 (framework regulation), which lays down that such material must not pose risks to human health. This must be guaranteed by the enterprises, irrespective of the particle size of the substances applied and of the kind of material. Substance-specific approval processes (principle of ban, subject to the possibility of authorization), with particle size as a criterion, are currently included in EU-legislation for certain components

in plastic food contact materials (Guideline 2002/72/EC) and components of regenerated cellulose (Guideline 2007/42/EC). In future, also substances in so-called active and intelligent materials or objects will require authorization (Regulation (EC) No. 450/2009). Whether additional nanotechnological special regulations for food contact materials will be necessary depends on further-gained insights.

Feeding stuff

Feeding stuff containing artificial nanoparticles is covered by the safety requirements of the Regulation (EC) No. 178/2002 and of the LFGB. Furthermore, feed additives get unique Europe-wide approval according to the Regulation (EC) No. 1831/2003. The approval applications for feed additives must contain an exact description of both the production process and the product itself. If these data indicate that nanosized particles are contained, this aspect is taken into account in the evaluation of the feed additive's safety for humans, animals and the environment. If there are doubts about the safety of the feed additive, the approval will not be granted. In connection with the approval of additives, also regulations regarding their labeling can be determined.

Plant protection, pesticides and biocides

The framework conditions for the field of "Plant Protection/Pesticides" are generally covered by applicable EU-law and the national plant protection law. Suitable test methods for special issues are still to be devised (OECD-test methods). The same applies, mutatis mutandis, to biocides according to the EU-guideline 98/8EC.

Cosmetics

The Regulation (EC) No. 1223/2009, the nanorelevant provisions of which need to be applied from 2013 on, contains for the first time regulations regarding nanomaterials in cosmetic agents. It includes a definition for nanomaterials that leans towards the definition of the Scientific Committee on Consumer Products (SCCP), a labeling requirement as well as a notification procedure, which is to be carried out by the EU-Commission before the product is placed on the market and which shall include a number of additional information. This information refers to the particle size, to toxicological aspects and to the quantity of the amount that shall be brought to the market. The Commission committed itself to compile a list of all nanomaterials which are intended for use in cosmetic means.

Drugs and medical products

For the field of drugs and medical products, the framework conditions are already covered by the applicable EU-law and the national law. New regulations are not required, the addition of individual nanospecific aspects, e.g. in evaluation processes, depends on further insights.

Market transparency for nanoproducts

Regarding the issue of obligatory labeling of nanoproducts, a general and overall regulation seems not to be effective. It is rather appropriate to examine the individual case and with regard to product classes, whether for reasons of consumer protection labeling is appropriate and required. Even though labeling can contribute to an information-based decision of the consumer, it can also be misunderstood as a warning. Moreover, the mere labeling as "nanoproduct" has no

information value, since this parameter allows neither a statement about the risk nor about the quality of the product. In order to avoid such misunderstandings, the prior objective should be the comprehensive information of consumers about the pros and cons of nanotechnological applications.

In addition to the labeling of nanoproducts, the introduction of a product register is under discussion. With regard to the European internal market, this is also being discussed on European level. If so, such a register could be used by authorities to inform the citizens. When weighing up advantages and disadvantages of a register, legal regulations already existing in the individual sectors, as e.g. compulsory authorization, need to be considered. The Federal Government will actively accompany this discussion process on the European level.

Voluntary labeling of textiles tested by the Hohenstein Institute

7.2 Standardization

Standards can open up markets for innovative technologies and provide market transparency. Thus they contribute directly to an increase in competitiveness and in the innovative strength of the enterprises involved. The increasing activities in nanotechnology require definitions and consistent terminology. So far, the different organizations use different definitions (see Chapter 1).

On the international level, the ISO (International Standardization Organization) and the IEC (International Electrotechnical Commission) are dealing with the standardization of nanotechnology. On the European level (CEN and/or CENELEC) and on the national level (DIN and/or DKE), the respective mirror committees exist, which closely cooperate with the ISO/IEC-committees and which introduce the respective European and national interest into the international committees [33]. By the end of 2010, ISO had published eleven official standards:

- **ISO 10801:2010 Nanotechnologies – Generation of metal nanoparticles for inhalation toxicity testing using the evaporation/condensation method**
- **ISO 10808:2010 Nanotechnologies – Characterization of nanoparticles in inhalation exposure chambers for inhalation toxicity testing**
- **ISO/TS 10867:2010 Nanotechnologies – Characterization of single-wall carbon nanotubes using near infrared photoluminescence spectroscopy**
- **ISO/TS 11251:2010 Nanotechnologies – Characterization of volatile components in single-wall carbon nanotube samples using evolved gas analysis/gas chromatograph-mass spectrometry**
- **ISO/TS 11360:2010 Nanotechnologies – Methodology for the classification and categorization of nanomaterials**
- **ISO/TS 12802:2010 Nanotechnologies – Model taxonomic framework for use in developing vocabularies – Core concepts**
- **ISO/TR 12885:2008 Nanotechnologies – Health and safety practices in occupational settings relevant to nanotechnologies**
- **ISO/TS 27687:2008 Nanotechnologies – Terminology and definitions for nano-objects -- Nanoparticle, nanofibre and nanoplate**
- **ISO 29701:2010 Nanotechnologies – Endotoxin test on nanomaterial samples for in vitro systems -- Limulus amebocyte lysate (LAL) test**
- **ISO/TS 80004-1:2010 Nanotechnologies – Vocabulary – Part 1: Core terms**
- **ISO/TS 80004-3:2010 Nanotechnologies – Vocabulary – Part 3: Carbon nano-objects**

ISO/TS 27687 and CEN ISO/TS 27687 have been publicly available in German language as national standard DI SPEC 1121 since January 2010.

With standards, the Federal Government has taken several measures for the improvement of technology transfer. In addition to the already successfully established funding project "Innovation with Standards", another funding priority was established with the programme "Transfer of R&D-Results Through Standardization". The objective of the programme initiated in 2009 is the intensified use of standards as a transmission belt for innovative ideas and research results on the way to marketable and successful products and services.

Actions

- **German participation in international standardization activities**
  The international standardization activities in the nanotechnologies are carried out mainly in two ISO- and IEC-committees (ISO/TC 229 "Nanotechnologies" and IEC/TC 113 "Nanotechnology Standardization for Electrical and Electronic Products and Systems") and in one European Committee (CEN/TC 352 "Nanotechnologies"). Parallel to the published standards mentioned above, more than 30 standardization projects are currently being dealt with in ISO/TC 229. The European CEN/TC works on three own standardization projects and includes many of the ISO/TC 229 projects into its work programme, thus after their completion they could become European Standards. Germany has assumed the management of the IEC/TC 113 secretariat, where currently four standardization projects are worked on. In future, this position ought to be used and expanded through the active commitment of German experts in the respective standardization committees, in order to actively participate in the standardization of nanotechnolgical solutions.

- **Standardization in research funding**
  The further improvement of the framework conditions for the successful transfer of research and development results into innovative products and services requires a closer consideration of standardization aspects in nanotechnology research programmes. By including the standardization relevance into the call for proposal and the evaluation of funding measures, the awareness of standardization as a transfer instrument for innovations can be sharpened and the effectiveness of public and private R&D-means can be increased. The Federal Government plans to take greater account of the special interests of small and medium-sized enterprises in the standardization committees and to extent the application range of standards on the European and national level.

7.3 Qualified Junior Staff and Workforce

7.3.1 School, Education and Science

The transfer of nanotechnology innovations into marketable products of tomorrow requires great minds and innovative ideas. The promotion of young researchers for future nanotechnologically oriented workplaces and well-trained qualified employees are essential prerequisites for the safeguarding of employment in Germany.

Young people shall therefore be enthused for nanotechnology and the related job opportunities. With the choice of the adequate vocational training or relevant university studies, young people can lay the foundation for a career in nanotechnology.

According to the forecasts of the German Institute for Economic Research, each year more than 100,000 so-called MINT-academics will be needed by 2020, a demand that cannot be met

by far by the about 85,000 to 90,000 graduates in mathematics, informatics, natural sciences and technology (MINT) that are to be expected each year. The demand clearly exceeds the number of graduates and there is no trend reversal in sight. This is accompanied by good prospects for future-proof workplaces with attractive career opportunities. In order to accommodate the growing manpower requirement, demand-oriented educational offerings are being developed, which prepare specifically for professional activities in the field of nanotechnology. Young people are required who are interested in research, innovative fields of activity and innovative companies. The measures of the Federal Government are, inter alia, aimed at:

- **promoting talents and enthusing young people about nanotechnology**
- **initiating educational offerings and making them transparent,**
- **communicating promising opportunities for potential junior staff and**
- **creating good framework conditions for the communication of nanospecific competences.**

Infoterminal for educational offerings on nanotechnology

Actions

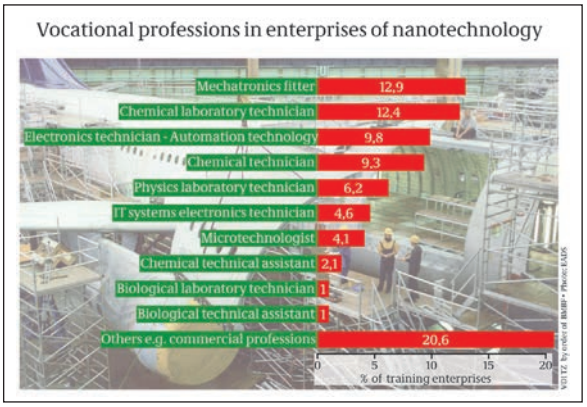
- **Information provided on study and career options**
  Educational offerings on nano are the trend and increasingly provided in the fields of physics, chemistry, materials sciences/materials, electrical engineering/informatics and engineering sciences. Corresponding in-depth information on the career choice is provided by the employment agencies in their job information centers, as for example in information leaflets called "Durchstarten". An overview of nano-educational offerings provided by the BMBF is accessible via the internet portal www.nano-bildungslandschaften.de. The interactive search for the suitable offer is cartographically visualized. Portraits on the nano-courses of study facilitate the choice and emphasize different orientations. Youth and university magazines as well as youth-related internet portals, as for example the offer www.abi.de of the Federal Employment Agency, reach the potential young researchers with editorials, reports and news on nanotechnology for each target group. The magazine "Nanotechnologie Aktuell" gives multifaceted insight in research, career paths and competences in nanotechnology. Prospects on studies, jobs, work and applications are imparted on a targeted basis.

- **Girls' Day**
  The „Girls' Day" funded by the Federal Ministry for Family Affairs, Senior Citizens, Woman and Youth and the Federal Ministry of Education and Research makes an important contribution to an increasing share of the female employment potential in MINT-jobs, which are also the basis for occupational activities in the field of nanotechnology. Each year in April, enterprises, companies, universities and research centers invite school girls from the fifth class upwards, in order to arouse interest in professional fields girls seldom take into consideration. With this, the action day provides an adequate and verifiably successful opportunity to attract female junior specialists, in particular to the MINT-field: due to their Girl's Day-activities, 10% of the participating companies and institutions could already employ one or more young woman in these jobs [34].

Awards ceremony with the winners of the BMBF-competition Nano-Futur

- **Funding of young scientists "NanoMatFutur"**
  Already since 2002, young scientists, qualified in nano and materials technologies, have been funded by the BMBF through the competition "NanoFutur", which shall now be continued as NanoMatFutur. Selected award winners get the opportunity to establish their own junior groups over a period of six years and to advance research works [35]. With this, they qualify for a scientific career; in their working groups, they train engineers and natural scientists both for industrial and academic careers.

- **Qualified employees for SME**
  The innovative strength of nano-enterprises – in particular of SME – not only depends on the adequate availability of skilled staff, but to a great extent also on their targeted education and training. Educational offerings are needed, which are aimed at future qualification requirements and the needs of innovative enterprises. Surveys on nano-educational offerings and their perception, career networks as well as analyses on nano-competence requirements provide a solid base to better dovetail educational offering and demand.



- **Industrial education**
  At the medium qualification level, nano-enterprises provide education in a broad spectrum according to the respective sector of industry. Currently, the top priority is imparting nanotechnological knowledge to mechatronics fitters and laboratory technicians, followed by electronics and chemical technicians. From the economic point of view, nanospecific training contents in the framework of already established skilled professions are required in the medium term.

- **Qualification initiative**
  With education, qualification and junior programmes, the Federal Government aims at providing proper framework conditions for a solid basis of skilled staff. For the mobilization of skilled employees, the Federal Government relies on the qualification initiative "Aufstieg durch Bildung" (Advancement Through Education) as well as on action programmes to secure jobs, to strengthen the capacity of growth and to broaden the basis of skilled employees. In the nanotechnology field, economy is facing a strongly growing need for highly qualified skilled workforce. It is expected that by 2015, almost each industrial sector will be influenced by nanotechnology. It is important to meet the increasing manpower requirements, to arouse young people's interest in nanotechnology at an early stage, to support talents and to facilitate the access for highly qualified professionals from all over the world.

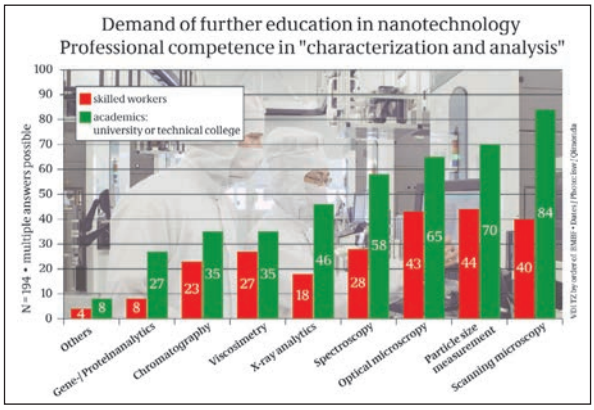
7.3.2 Advanced Vocational Training

Currently, about every second person employed in nano-enterprises is a university graduate. Skilled workers account for 20 % of the staff and the trend is rising. Small and medium-sized nanotechnology enterprises expect a demand of about 15,000 additional employees in the next five years. In future, the number of companies, of the industries involved and of the product diversity will further increase. The Federal Government will increase its commitment in order to support excellence in education and research and thus to make a contribution to enable sufficient highly qualified skilled workers of nanotechnology to be qualified and employed at the location Germany.

Actions

- **Development of qualification measures suitable for the respective target group**
  Innovative nano-enterprises develop technological processes with new job profiles and new nanospecific qualification requirements for employees. In future, this dynamics will lead to an increased demand for nanospecific qualifications. Tailor-made nanospecific qualification offerings however are still poorly developed. Nano-enterprises often rely on direct cooperations with external knowledge carriers from universities, universities of applied sciences and research institutes. The Federal Government will enhance accompanying measures in order to meet the future qualification demand.

- **Communication of corporate nano-qualification requirements**
  First analyses on behalf of the BMBF on the qualification requirements of nano-enterprises provide ideas for the orientation of future qualification measures with regard to the professional and societal expectations, in particular in small and medium-sized enterprises. Currently, there is particular demand for expertise in scanning microscopy, particle size measuring and optical microscopy in the field of characterization and analysis, a priority area for nano-researchers and developers. In addition, methodical and social competences are desired, such as project management, English language skills, interdisciplinary thinking and the capacity for teamwork. The respective qualification profiles of the employees are increasingly in demand [36]. The Federal Government will continue to observe the requirements and communicate new developments to the respective target group.

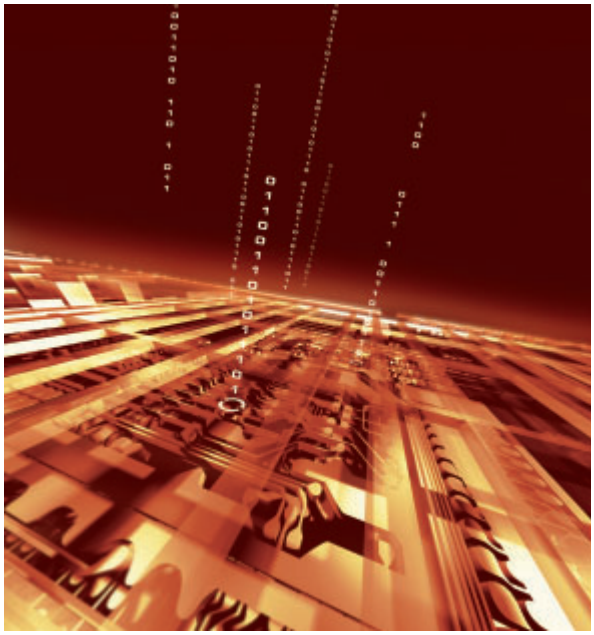


- **Analyses on the careers of nano-graduates**
  Further education of already well-trained skilled workers aims at innovative capability and permanent employment. Field reports and analyses on the occupational careers of the respective graduates as well as the target-group related presentation and communication of attractive career prospects arouse interest and offer incentives, they can contribute to nano-specific career orientation and provide orientation for the occupational development in the future field of nanotechnology. Extension studies on the professional activities of students of nanotechnological study paths are planned. They are likely to provide further information on nanotechnologically characterized fields of activity and the requirement for nanospecific training-in and further education.

8 Intensifying Communication – Conducting Dialogues

8.1 Information

As one of the most promising fields of innovation, nanotechnology not only requires the commitment of research and development for its effectiveness, but also the targeted information and communication with effect on the public. The Federal Government provides new insights in interdisciplinary oriented nanotechnology in different ways. These include trade media, internet portals, publications, brochures and exhibitions. One focus of activity is on attracting potential young researchers.



Nanoreisen interactively provides virtual expeditions to the nanocosmos (www.nanoreisen.de)

Actions

- **Trade media for pupils and students**
  Information centers for competence and career, suitable trade media with nanotechnological contents, multipliers and other partners make contributions in order to facilitate young people's access to nanotechnology. Road shows of universities directly address prospective students.

On www.nanoreisen.de, the BMBF already provides virtual online-trips to the smallest known dimensions of our cosmos. The multi-award winning interactive offer was developed with the particular aim of arousing the interest of young people in "Abenteuer hinter dem Komma" (adventures behind the comma). The Federal Government will further develop proven information and communication offers, initiate new demand-oriented offers and provide support with addressing their target groups.

- **Trade media for the interested public**
  The aim of the DaNa project [37] is to prepare research results on nanomaterials and their impact on humans and environment in an interdisciplinary approach with scientists of human toxicology, ecotoxicology, biology, physics and chemistry in a way that it can be understood by interested laypeople. For this purpose, the already existing internet knowledge platform www.nanopartikel.info was continued and extended.

Roadshow "Expedition Materia"

- **Museums and special exhibitions**
  Nanotechnology increasingly conquers even big technology museums, such as the Deutsche Museum (German Museum) in Munich with permanent exhibitions in the "New Technologies Center" and the State Museum of Technology and Labor in Mannheim with a special exhibition on benefits and visions of nanotechnology. In 2011, this will also be shown in the "DASA Arbeitswelt" exhibition of the BAuA with a framework programme – including also consulting services for start-up enterprises. In addition, the DASA showcases the Nano-topic in parts of the permanent exhibition. The BMBF presents the world of innovative materials in the road show "Expedition Materia" in an illustrative way showing a number of exhibits. Nanotechnology and materials research are not only imparted as the basis of many industrial developments, but also as the basis of everyday life.

Mobile information campaign "nanoTruck" (www.nanotruck.de)

- **BMBF nanoTruck-initiative**
  According to the motto "Hightech from the Nano-cosmos", the nanoTruck initiative of the BMBF allows the rapid development of this future technology to be directly experienced. On its tour through Germany, the nanoTruck reaches in particular young people and informs about chances, interesting career paths and exciting fields of work on nanotechnology as well as about new processes, products, risks and application prospects. The aim of the nanoTruck-initiative is to take nanotechnology out of the laboratories and to bring it to the people directly on the spot.

8.2 Dialogue Processes

A wide variety of interactive communication offerings shall be provided to interested citizens and dialogue options shall be further developed to enable nanospecific risks to be assessed and chances for science, economy, job and society to be objectively evaluated, discussed and used. Examples for this are consumer conferences which influence public opinion and where citizens get the direct opportunity to speak.

8.2.1 The Dialogue with Citizens

The Federal Government supports dialogues with citizens, in which interested citizens can both get objective information and are heard at an early stage. The discussion with experts offers citizens the opportunity to make suggestions for the future orientation of this topical area.

Dialogue with citizens on chances and risks of nanotechnology

Actions

- **NanoCare dialogues with citizens**
  The aim of the NanoCare dialogues is to impart current research results of BMBF-projects on risk research in nanotechnology to citizens and discuss them with them. Here, experts of research and development involved in the projects are at the disposal of the citizens for a direct exchange and for answering their questions.

- **Dialogue process with citizens within the framework of the Hightech-Strategy**
  The BMBF also plans dialogues with citizens, with the focus going beyond the discussion of results of risk research. This dialogue process shall comprise elements such as target group dialogues, citizens' consultations, online-dialogues or citizen appraisals. Nanotechnology was identified as one issue, since it is one of the important areas of BMBF research funding. The focus of the dialogue is on the application fields of nanotechnology and nanomaterials, for example in cosmetics or textiles.

8.2.2 The Dialogue with Stakeholders and Non-Governmental Organizations

- **NanoDialogue**
  Already in 2006 within the framework of the "Nano-Initiative – Action Plan 2010", the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has appointed the NanoCommission of the German Federal Government. The Nano-Commission conducts the NanoDialogue, a stakeholder-dialogue, involving science, economy, politics, churches, environmental and consumer associations. The nano-commission has set the focus of its work on four thematic groups:

- **Development and support of a principles paper on the handling of nanomaterials in the production process and their integration into products.**
- **Presentation and discussion of chances and risks with the example of a market-relevant product range and a "novel type" of nanomaterials**
- **Support of the regulation debate in the field of nanomaterials on national and EU-level**
- **Contribution to a provisional risk assessment of nanomaterials**

In thematic groups, contributions to the public discussion about chances and risks of handling nanomaterials and instruments for the support of their responsible handling are developped. Results of the current commission have been considered in the preparation of the Action Plan. The second phase of the NanoCommission will be concluded with the final event at the beginning of 2011.

- **Activities of the BfR in the field of risk communication**
  One focus of the BfR is the work on nanotechnology risk communication; partners of the dialogue are consumers, scientists, internet users or journalists. The BfR started to deal with the question of how public and media perceive nanotechnology at an early stage and has carried out several research projects and studies on these issues [29]:

- **Delphi-expert survey on the "risks of nanotechnological applications in the fields of food, cosmetics and consumer goods"**
- **BfR-consumer conference on nanotechnology in food, cosmetics and textiles**
- **Representative survey on the perception of nanotechnology by the public**
- **Analysis of the presentation of nanotechnology in the media**
- **Analysis of the perception of nanotechnology in internet-based discussions**
- **BfR-Forum Consumer Protection "nanotechnology in the focus of health-related consumer protection"**

Participative Governance
The project "Participative Governance: opportunities, impacts and limits of participation of civil-society actors with biomedicine and nanotechnology as examples" funded by the BMBF within the framework of science research has the aim to contribute to a more profound social-science based understanding of the emergence conditions, forms, potentials, problems and limits of participative governance of science. Comparing case studies on biomedicine and nanotechnology shall be used to survey the conditions and aims of actors of the civil society for their participation in the organization of research and technical development, the effects of it and how this changes the relationship between science, politics and society [38].

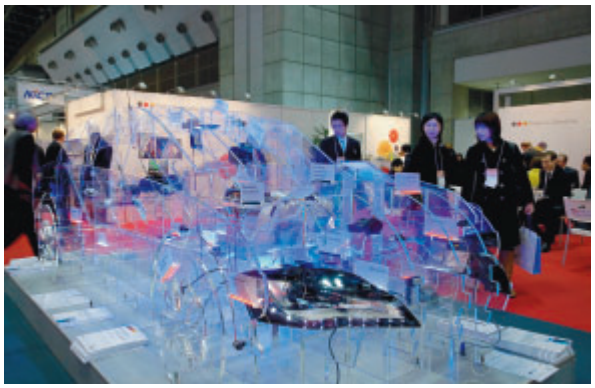
Visualizing Risk Controversies
For many societal actors, political discussions – also about the potential risks in connection with nanotechnology – are difficult to access. In order to provide the general public with access to disputes, central arguments and various positions of different actors as well as to the numerous risk relationships, a team of sociologists, computer scientists and partners from practice developed so-called "Argumentation Maps" within the project "Risk Controversies Visualized" funded by the BMBF within the framework of the "social ecological research programme": With a click of the mouse, the user of the website http://riskcart.wzu.uni-augsburg can get to know the different aspects of and important information on the discussion about nanotechnology. The aim of the cartography is to enable all people involved to participate in the societal organization of risk handling. The argumentation maps show complex contents in a way that the relationships which have been unknown so far and different interactions of the risk debate become visible.

9 Extending Germany's Top Position through International Cooperation

Globalization and the resulting global division of labor have far-reaching economic and social impacts. Apart from the support for research and development in the own country, this also requires the increased use of new opportunities provided by internationalization. More than 90% of the worldwide knowledge is not generated in Germany. Thus with regard to innovations and workplaces, it is necessary to make this globally existing knowledge more easily available to Germany. The international networking of nanotechnology is decisive for its utilization and development even beyond the questions of knowledge generation. Almost all laws concerning nanomaterials are created at European level; the standardization occurs in international committees and companies or company start-ups and their financing almost always takes place in an international context. Last but not least, international research cooperations are of vital importance for Germany.

The Action Plan Nanotechnology contributes considerably to the realization of the Federal Government's strategy to internationalize science and research. The Strategy for the Internationalization of Science and Research aims to achieve a participation rate of 20% for international cooperation in sector programmes. The objective of the Federal Government is to internationally visualize research and funding policy on nanotechnology in Germany for strategic target markets in order to support value added chains. Therefore, findings in the nanotechnology scene of the respective target regions (Asia, North and South America, Oceania) are gathered as a basis for the initiation of adequate international research cooperations.

Germany Trade & Invest (GTAI)
For Germany Trade & Invest, the Federal location development agency, nanotechnology is an important element for the presentation of the competitiveness of German economy in the future technologies. Nanotechnology is regarded as innovation driver and provider of solutions in the most competitive sectors of German economy, such as mechanical engineering, electric engineering, optics, car manufacturing as well as chemistry and pharmaceuticals. The great demand for new products and processes in these sectors is also a stimulus for foreign companies to integrate themselves via cooperations, joint ventures and direct investments into existing German value added chains. Here, the GTAI is focused on the fields of nanoanalytics and photonics, organic electronics, new materials and environmental technologies, medical technology and nano-biotechnology and finally, on the next generation of photovoltaics. In this context, the target groups are in particular globally thinking, innovative small and medium-sized enterprises [39].



Glass exhibit with automobile applications as exhibition object

Trade fairs
Trade fairs with significantly international appeal contribute decisively to the increased visibility of German nanotechnology. The concentrated appearance on joint German exhibition booths (German Area – BMBF – in particular for young enterprises and research groups; German Pavilion – BMWI – for industrially oriented presentations) turned out to be successful.

9.1 Activities within the Framework of the European Union

Apart from the funding programmes of the Federal Government, the research framework programme of the European Union is the most important source for publically financed research funding in the field of nanotechnology in Germany. The total funding amount of the 6th Research Framework Programme amounted to altogether almost 1.4 billion Euro. Since 2007, more than 1.1 billion Euro have been invested in the field of nanotechnology within the context of the 7th Research Framework Programme [40]. A significant part of this amount went to enterprises and academic research institutions in Germany. In the field of industrial collaborative research, for example, the share of German partners in the funding amount was always about 20 %.

In the next five years, important strategy decisions will be taken on European level. Contemporarily to the Action Plan of the Federal Government, the EU-commission publishes a "European Roadmap for Innovating with Nanotechnologies 2011-2015", which will put more focus on the industrial implementation and the innovation environment of nanotechnology-based processes and products. With the preparation of the 8th Research Framework Programme starting in 2014, also important decisions regarding public research funding in the field of nanotechnology will be taken.

Actions

The Federal Government will support the European Commission in the implementation of the Nanotechnology Roadmap 2011-2015 of the EU:

- **German participation in the networking of national activities for the joint research of chances and risks of nanotechnology.**
- **German participation in transnational funding measures for nanotechnology, e.g. ERA-NET EuroNanoMed and the ERA-NET SIINN (Safe Implementation of Innovative Nanoscience and Nanotechnology)**
- **Cooperation in the identification of research topics of national and European relevance, in order to use synergy effects and to avoid double funding**
- **Constructive cooperation in the improvement of societal framework conditions and the reduction of innovation barriers in Europe (e.g. regulation processes REACH, standardization and norming, venture capital).**

The aim of the Federal Government is the establishment of a responsible, integrated and economy-friendly innovation environment for nanotechnology in Europe.

The Federal Government will continue to support the strong participation of German institutions in the Research Framework Programmes of the EU and thus sustain the access of German partners to the results of European R&D-activities in the field of nanotechnology.

- **The work of the National Contact Point Nanotechnology in the 7th Research Framework Programme as an important instrument with the aim of a continued strong participation of Germany within the context of the EU-research funding**
- **Intensive participation in the preparation and implementation of nanotechnological research funding activities in the 8th EU-Framework Programme**
- **Networking of existing research activities and results**

The Federal Government will furthermore ensure the unified representation of German interests at EU-level through the coordination between the Federal Ministries.

9.2 Activities within the Framework of the Organization for Economic Cooperation and Development (OECD)

The increasing intensive utilization of nanotechnology requires a coordinated approach also on the international level in order to ensure the environmentally friendly and healthy as well as sustainable development of nanotechnology. A prerequisite is the realistic assessment of chances and risks as well as a detailed consideration of different methods and materials. Although a number of research initiatives regarding possible health and environmental risks caused by nanomaterials were set up in recent years, there are still knowledge gaps, in particular due to methodological reasons, since there are still no standardized tests. In this context, the international coordination of test methods and data is of particular importance, which may possibly result in regulatory measures. Concentrated international cooperation can help closing the numerous knowledge gaps, because only internationally acknowledged processes enable the trade and safe use of nanomaterials beyond international borders.

Against this background, the "Working Party on Manufactured Nanomaterials (WPMN)" of the "Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology" of the OECD was established in 2006. Aim of the Working Party is to deal with safety issues around nanomaterials within the framework of international cooperations. The Working Party consists of more than 100 experts of different stakeholders from OECD-member states, but also of non-member states and experts of organizations like the UNEP, WHO, ISO, BIAC, TUAC and environmental authorities. Within the framework of the WPMN, different working parties shall be addressed already at an early stage of safety research into nanomaterials, in order to simultaneously accompany technical progress. One of the topics of the WPMN is the "Sponsorship Programme". Here, technical dossiers on representative nanomaterials are prepared under the responsibility of the states involved and knowledge gaps are closed through internal research. Interim results of the individual parties are already available and published [31]. The results achieved by the WPMN are also incorporated in the national and international debate on risk assessment and regulation.

In 2007, the OECD established another working party on nanotechnology (Working Party on Nanotechnology, WPN) under the umbrella of the Committee for Scientific and Technological Policy (CSTP). Members are representatives from 26 nations, as well as from the EU, ISO, BRIC and BIAC. The WPN acts as policy guidance committee on issues regarding the responsible global development of nanotechnology. In the WPN, topics such as scientific and economic indicators, analysis of national policies, identification of innovation barriers and challenges for the implementation of results, contributions of nanotechnology to cope with global problems, international cooperation, education, public dialogue and politics forums are discussed with regard to internationally important political matters. In the WPN, Germany is represented by the BMBF. Contents and results of the working parties are publically available [41].

OECD Working Party on Nanotechnology

Actions

- **German cooperation in the OECD WPMN**
  Germany sends a delegation to the WPMN, consisting of representatives of federal authorities and research institutes with expertise in research on safety of nanomaterials. This delegation can make contributions to all topics the WPMN is dealing with. The Federal Ministry of the Environment has assumed the chairmanship of the German delegation. Germany, together with France, is the responsible nation for the processing of titanium dioxide within the Sponsorship Programme and, in addition, contributes to the research on environmental risks caused by nanosilver. Moreover, data on zinc oxide, aluminum oxide and cerium oxide as well as on carbon nanotubes (CNTs) are provided.

- **German cooperation in the OECD WPN**
  With a representative of the BMBF, who is also a representative of the steering group, Germany will continue to play an active role in the work of the WPN. Here, the required basic information of the German nanotechnology support and actors are worked out for international comparison and submitted for use in OECD surveys. OECD-information is used to sustain the funding strategy of different ministerial departments. Currently, the work of the WPN addresses different project fields which are dealing, in particular, with the development of indicators and the provision of statistical data, the analysis of national policies, the identification and analysis of innovation barriers as well as with the contributions nanotechnology can make to address global challenges.

List of Endnotes

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Further Information

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Nanotechnology-relevant institutions www.nano-map.de

Research Communication Nanotechnology www.nanotruck.de

Educational Offerings Nanotechnology www.nano-bildungslandschaften.de

Virtual Trips to the Nanocosmos www.nanoreisen.de

Teaching with Digital Media – Nanotechnology www.naturwissenschaften-entdecken.de

Ways to Study and Career – Nanotechnology www.abi.de

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Risk Research into Nanotechnology www.nanopartikel.info

Information of the Federal Institute for Occupational Safety and Health (BAuA) on Nanomaterials www.baua.de/nanotechnologie

Federal Institute for Risk Assessment (BfR): Selected Questions and Answers on Nanotechnology www.bfr.bund.de/cd/8552

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List of Abbreviations

ANKA	Angströmquelle Karlsruhe
BAM	Federal Institute for Materials Research and Testing
BAuA	Federal Institute for Occupational Safety and Health
BER	Research reactor for neutron beams at the Helmholtz Center Berlin
BESSY	Berliner Elektronenspeicherring-Gesellschaft für Synchrotron-strahlung
BfR	Federal Institute for Risk Assess-ment
BIAC	Independent International Business Association
BMBF	Federal Ministry of Education and Research
BMU	Federal Ministry for the Environ-ment, Nature Conservation and Nuclear Safety
BRIC-States	Brazil, Russia, India, China
CARACAL	Competent Authorities for REACH and CLP
CASG	Nano Competent Authorities Subgroup Nano
CEN	European Committee for Standardization
CENELEC	European Committee for Electro-technical Standardization
CERN	Geneva European Organization for Nuclear Research
CLP	Regulation on Classification, Labeling and Packaging
CNT	Carbon Nanotubes
CSTP	Committee for Scientific and Technological Policy
DaNa	Acquisition, evaluation and public-oriented presentation of society-relevant data and findings relating to nanomaterials
DESY Hamburg	Deutsches Elektronen-Synchrotron
DKE	German Commission for Electrical, Electronic & Information Technologies DIN und VDE
DIN	German Institute for Standardi-zation (incorp. association)
DORIS	Double-ring storage at the DESY
EFSA	European Food Safety Authority
ERA	European Research Area
FLASH	Free electron laser, Hamburg Hamburg
ForMaT	Forschung für den Markt im Team (Research for the Market in Teams)
FRM	Research reactor Munich
FZJ	Research Center Munich
GKSS	Helmholtz-Center Geesthacht
GSI Darmstadt	GSI Center for Heavy Ion Research
GTAI	Germany Trade &Invest
HFR	High-flux reactor
HTGF	High-Tech Gründerfonds
HZB Berlin	Helmholtz-Center Berlin for materials and energy
IEC	International Electrotechnical Commission
ILL	Grenoble Institute Laue-Langevin
ISO	International Organization for Standardization
ISOLDE	Isotope On-Line Detector
ITO	Indium Tin Oxide
JKI	Julius-Kühn-Institute
KIT Karlsruhe	Karlsruhe Institute of Technology
KMU	Small and medium-sized enterprises (SME)
LFGB	German Food and Feed Code
LZH	Laser Center Hanover
MRI	Max Rubner-Institute
NEnA	Nano-Entrepreneurship-Academies
OECD	Organization for Economic Co-operation and Development
OLED	Organic light-emitting diodes
OPV	Organic photovoltaics
PETRA	Positron-Electron Tandem Ring Accelerator at DESY
PTB	Federal Institute of Physics and Metrology
REACH	(Registration, Evaluation, Authorization and Restriction of Chemical Substances)
SIS	Synchrotron at GSI
TUAC	Trade Union Advisory Committee
TUM München	University of Technology, Munich
UBA	Federal Environment Office
UNEP	United Nations Environment Programme
UNILAC	Universal Linear Accelerator
VDI	Association of German Engineers
vTI	Johann Heinrich von Thünen-Institute
WHO	World Health Organization
WPMN	Working Party on Manufactured Nanomaterials
WPN	Working Party on Nano-technology
XFEL	X-Ray Free Electron Laser

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