



metal oxide particles | © Pressefoto BASF SE

## Nanotechnology

Germany has a rich and diverse nanotech landscape, with industry players of all sizes catering to the strong demand for nanotechnology both in our domestic markets - especially the automotive, optical, chemical, and pharmaceutical industries - and abroad. We continue to enhance our already strong international reputation for scientific expertise. Moreover, our government puts more funding behind this industry than any other country in Europe and has generous new initiatives aimed at expanding and solidifying our lead. Take a look at our numbers and see what we have to offer. We'll find a place for you - and your parts - too!

### Nanotechnology in Germany

- Approximately half of the nanotechnology companies in Europe are from Germany; the country is number one in Europe in the nanotechnology industry.
- With R&D expenditures amounting to 10 percent of total turnover, nanotechnology is one of the most innovative technology sectors in Germany.
- German companies manufacture products in the areas of nanomaterials, nanotools, nanoanalytics, and nanotools accessories (e.g. vacuum and cleanroom technology, plasma sources, etc.). They also manufacture and utilize nano-optimized components and systems, and they provide services in the areas of consulting, contract coating, technology transfer, and commissioned analysis and research

- With federal nanotechnology subsidies amounting to approximately EUR 400 million in 2010, Germany was ranked fourth internationally, behind the USA, Russia, and Japan. In terms of scientific publications, Germany also ranked fourth, behind the USA, China, and Japan. In international patent rankings, the OECD puts Germany in third place, behind the USA and Japan.
- German partners were also extremely successful in the competition for European subsidies. During the sixth and still-ongoing seventh calls for proposals as part of the EU Framework Programs for Research and Technological Development, German partners placed first in terms of the amount of subsidies received. German industry demonstrated a relatively high rate of participation in these projects; this participation rate was consistently above the overall EU average.

## Key Players

- The nanotechnology industry in Germany comprises about 2,000 key players: approximately 40 percent of these are small and medium-sized enterprises (SMEs), 13 percent are large companies, 24 percent are university institutions, and 9 percent are research institutions or other organizations such as professional networks, government agencies, associations, or financial institutions (as of July 2012).
- The number of key nanotechnology players has increased by 50 percent since the end of 2008.
- The total number of employees in the industrial nanotechnology sector in Germany was estimated at 61,000 in 2010.
- Approximately 80 percent of nanotechnology companies are SMEs and start-ups; 70 percent have been founded in the years since 1985.

**Nano-Map** is an interactive map of nanotechnology expertise in Germany. Users can search for nanotechnology experts from small and medium-sized enterprises (SMEs), large companies, universities and research institutions, government agencies/associations, financial institutions, and media/museums. Search results can be sorted by region, application, and technology, and then displayed in clear and comprehensible maps. Detailed search filters allow for a specific search according to select fields of technology and application.

## Market Potential

- Total turnover generated by German nanotechnology companies in 2010 (most recent value) was estimated at EUR 13 billion.
- The companies are expecting turnover to grow by 8 percent, to EUR 14.3 billion, in 2011.
- German nanotechnology companies' research expenditures is forecast to reach EUR 1.3 billion in 2010: approximately 10% of companies' total turnover was invested in research. The companies have stated that they plan to increase their investments in research by 4 percent, to approximately EUR 1.4 billion, in 2011.

## Areas of Application & Technological Requirements

Foreign companies will find high demand for the following areas of application in Germany:

### 1. Energy Efficiency, Conservation of Resources

- Nanomaterials for adaptive facilities engineering
- Nanomaterials for a decentralized energy supply
- Improved filter technologies
- Nanomaterials for improved material efficiency, as substitutes for limited resources, and for recycling
- Hard-wearing, environmentally friendly friction materials
- New materials for sustainable water management

### 2. Production Technology

- Nanotechnology in production: dust-free manufacturing of nanoscale particles and processing into matrix materials
- Coating of surfaces
- Reliable online analytics in nanoscale
- New, reliable building components thanks to multi-scale simulation

### 3. Health

- Molecular imaging – innovative nanoscale contrast agents
- Integrated concepts for diagnosis and therapy (theranostics) thanks to the use of diagnostic sensors for therapeutic applications
- Tailored therapies and nanomedicine – new application systems for drug delivery
- Personalized implants and prosthetics for long-term rehabilitation
- Regenerative medicine and nanostructured biomaterials

### 4. Mobility

- Nanotechnology for cost-effective mobility that conserves resources
- Nanotechnology for electric vehicles
- Nanomaterials for intelligent roads

## 5. Communication

- Quantum communication as the basis for bug-proof communication
- Organic or printable electronics

## 6. Security

- Product identification and marking systems for the purpose of generating optical security features
- Decontamination and filtering technologies for protecting critical infrastructure and technical facilities
- Integrated protective systems for protecting police and emergency personnel from the effects of hazardous substances, explosions, fires, and projectiles

## Associations, Networks, & Strategic Alliances

### 1. Associations

The Deutsche Verband Nanotechnologie (German Nanotechnology Association, DV Nano) is the professional association for employees of the nanotechnology industry in academia, business, the media, education, politics, and management. The association views nanotechnology as an interdisciplinary field that combines experiences from technical and academic fields such as chemistry, physics, biology, and materials sciences.

The "Nano in Germany" initiative provides key players in the nanotechnology market with the opportunity to work together to improve their visibility and to increase the acceptance of nanotechnology in society based on its added value and the benefits it offers mankind. Domestic and international companies, organizations, associations, and research institutions use the "Nano in Germany" initiative as a common base for tapping the market.

### 2. Strategic Alliances

In cooperation with the BMBF, organizations in the business and science fields established five "Innovation Alliances" in the nanotechnology sector. These alliances set priorities in fields of technology that are important for the future. The Innovation Alliances also offer a special kind of leverage: The OLED and OPV initiatives alone have already generated EUR 1 billion worth of business with EURO 140 million in BMBF funding.

- **Innovation Alliance Carbon Nanotubes (Inno-CNT)**

In recent years, carbon nanotubes (CNT) have experienced rapid development thanks to their unique material properties. CNT can be used to create entirely new materials with spectacular properties. The Innovation Alliance Carbon Nanotubes (Inno.CNT) was founded with the support of the German Federal

Ministry of Education and Research for the purpose of making targeted use of this potential. The initiative's overarching goal is to establish materials technology in Germany as a key market for the future; materials technology will then serve as an international lead market for innovative carbon nanomaterials. For this purpose, an exceptionally large group composed of approximately 90 expert partners from industry and science have come together to form the highly effective, interdisciplinary Innovation Alliance Inno.CNT.

- **Innovation Alliance Organic LEDs (OLED)**

With the Innovation Alliance OLED 2015, the BMBF has been successfully promoting the development of OLED technology and linking R&D subsidies with concrete agreements on industrial investments since 2006. Particularly noteworthy here is the participating companies' commitment to make significant investments in Germany in addition to the EUR 100 million in R&D subsidies provided by the BMBF. The most recent indicator of the Alliance's success was the opening of the OSRAM OLED pilot production facility on August 30, 2011 in Regensburg. Merck's new materials research center in Darmstadt, the construction of Aixtron's new research center (including a pilot production line) in Herzogenrath, and Philips' OLED pilot production line in Aachen are a few more examples. In this way, the German federal government and businesses have invested more than EUR 800 million in the research and development of OLEDs in Germany.

- **Innovation Alliance Organic Photovoltaics (OPV)**

With the Innovation Alliance Organic Photovoltaics, the BMBF hopes to accelerate the development process for OPV technologies to the point where they can be broadly implemented in industrial applications. In order to achieve this goal, the Alliance uses a combination of fundamental research, practical materials R&D and process technology, and component-specific developments. The industry has invested an extraordinarily large share of its own finances into the Alliance.

- **Innovation Alliance Molecular Imaging**

The Innovation Alliance Molecular Imaging combines academic/clinical activities with technological/ industrial ones. The Innovation Alliance's partners, the BMBF and industry, will make a joint investment of EUR 900 million in molecular imaging as part of a technology initiative. Over the next ten years, the companies will commit EUR 750 million to the project; the BMBF is planning to support joint projects between business and academia – research institutions and universities – with up to EUR 150 million. One of the goals of the initiative is to produce new imaging probes – such as contrast agents or nuclear medicine tracers – new medical imaging devices, and new high-performance data processing and image analysis systems for clinical diagnostics and pharmaceutical development.

- **Innovation Alliance Lithium-Ion Batteries**

As part of the Innovation Alliance Lithium-Ion Batteries (LIB 2015), a consortium of companies including BASF, BOSCH, EVONIK, LiTec, and VW committed to investing EUR 360 million in the research and development of lithium-ion batteries in the coming years. At the same time, the BMBF will provide EUR 60 million in subsidies for this area.

## Security & Risk Assessment

In cooperation with industry, the **German Federal Ministry of Research and Education (BMBF)** is funding projects to close knowledge gaps and implementing measures to identify and minimize risks. From 2009 to 2013, 20 projects with a total volume of subsidies amounting to EUR 36 million were carried out.

The goal of the **NanoCare** subsidy program is to systematically conduct further research on the human toxicological effects and interactions of the manufacturing, processing, and application of synthetic nanomaterials.

The goal of the NanoNature subsidy program is to strengthen potential market segments for environmental applications of nanomaterials and to expand exports of materials and technologies relevant to the environment. The program also aims to continue systematically researching the introduction, distribution, location, and effect of synthetic nanomaterials in the environment and to develop customized measurement techniques.

In the context of its priority program, "Biological Responses to Nanoscale Particles," the **German Research Foundation (DFG)** promotes projects that focus on interactions between nanoparticles and biological systems.

Since 2011, the **QNano research program** has been researching the security of nanomaterials; 27 European institutions came together to form this organization.

## Political Support

### The German Federal Government's High-Tech Strategy

The goal of the High-Tech Strategy is to make Germany a pioneer in resolving the global challenges facing the fields of climate/energy, health/nutrition, mobility, security, and communication.

### Action Plan Nanotechnology 2015

With the Nano Initiative, which was launched in 2006 as part of the High-Tech Strategy, the German federal government is promoting consistent exploitation of the potential for added value that nanotechnology offers, in an effort to strengthen Germany as a location for innovation and technology. The Action Plan Nanotechnology 2015, which was published in January 2011, is an interdepartmental, integrated concept regarding the responsible use of nanotechnology in Germany.

### Joint Initiative for Research and Innovation

In June 2005, the heads of Germany's federal and state governments passed the Joint Initiative for Research and Innovation and the Excellence Initiative for Cutting-Edge Research at Institutions of Higher Education, with the goal of strengthening Germany's position as a location for science and research over the long term and fur-

ther improving the country's global competitiveness. These agreements include public sector approval for annual budget increases of a certain minimum percentage for the Max Planck Society (MPG), the Leibniz Association (WGL), the Helmholtz Association of German Research Centers (HGF), the Fraunhofer-Gesellschaft (FhG), and the German Research Foundation (DFG). While these budget increases amounted to at least 3 percent for the duration of the first Joint Initiative for Research and Innovation (until 2010), the heads of Germany's federal and state governments decided on June 4, 2009 to renew the Joint Initiative with annual budget increases of at least 5 percent during the years from 2011 to 2015. The federal and state governments plan to work in concert with these research institutions in the context of the Joint Initiative in order to meet the following research objectives:

## **Subsidies and Financing**

### **Public Funding for Nanotechnology**

The NanoChance Initiative supports individual and group projects in the nanotechnology field that take significant scientific or technological risks, that are practical, that involve a range of different technologies, and that are relevant to a company's market position. Support is provided in the form of a grant, generally for a period of up to two years. For commercial enterprises, this grant usually amounts to up to 50 percent of eligible costs.

### **Financial Sector and Private Venture Capital**

In Germany, approximately 75 venture capital companies are involved in the nanotechnology sector. These financial institutions predict that chemicals, electronics, medicine/pharmaceuticals, energy, and optics will be the areas of application with the greatest market potential for nanotechnology within the next five to ten years. Sixteen of the financial institutions surveyed currently hold shares in 41 nanotechnology companies; ten of these were acquired in 2009, while five were acquired in 2010. Most of the shareholders are based in Germany. The amounts invested cover a relatively broad range, between EUR 250,000 and more than EUR 5 million. The average amount invested is estimated at EUR 1.8 million. The investments were primarily made in the early stages of company development. A projection based on all investors active in the German nanotechnology sector estimates that a total of EUR 40 million in venture capital was invested in the industry in 2010.

## **Research & Development**

Nearly a third of all Fraunhofer institutes are involved in the nanotechnology field. The work of the Fraunhofer Nanotechnology Alliance covers the entire value chain, from practical research to industrial applications. Among other things, the Alliance is developing multi-functional coatings for optical applications, automotive engineering, and the electronics industry. Metallic and oxidic nanoparticles, carbon nanotubes, and nanocomposites are used in actuators, structural materials, and biomedical applications. The institutions in the Alliance are also working on issues of toxicity and the safe handling of nanoparticles.

In terms of key technologies, the Helmholtz Association is working to integrate nano- and microsystems. The Nano-Micro-Facility, which deals with nanomaterials and processes, was opened in Karlsruhe and is available for all Helmholtz institutions to use. The Helmholtz Center Munich is working specifically on issues of toxicology.

Several of the Max Planck institutions have already been working in the areas of nanomaterials, supramolecular systems, and characterization methods for years.

The Leibniz Association also boasts numerous institutions that have delivered excellent results in researching nanomaterials, surfaces, and opto- and nanoelectric properties.

## Skilled Personnel

Information on university faculties that offer nanotechnology as a subject area, as well as portraits of the available majors in nanotechnology and providers of further education that offer courses on nanotechnology are available online on the platform:

- [nano-bildungslandschaften](#) ▶

## Links & Downloads

### Associations and Interest Groups

- [Deutscher Verband Nanotechnologie \(German Nanotechnology Association\) \(German only\)](#): ▶
- [German National Academy of Science and Engineering \(Acatech\), Nanotechnology Network](#): ▶
- [IVAM Microtechnology Network](#): ▶
- [Joint Initiative for Research and Innovation \(German only\)](#): ▶
- ["Nano in Germany" interest group \(partly Englisch/German\)](#): ▶
- [Working group of the Centers of Competence of Nanotechnology in Germany \(AgeNT-D\)](#): ▶

### German Clusters

- [Center for Applied Nanotechnology \(CAN\), Hamburg](#): ▶
- [Center for Nanotechnology \(CenTech\), Münster](#): ▶
- [Competence Center for the Application of Nanostructures in Optoelectronics Berlin](#): ▶



- Excellence Network NanoBioTechnology (Ennab) Bavaria (German only): ▶
- Fraunhofer Innovation Cluster "Nano for Production": ▶
- Interdisciplinary Nano-Research Center Hamburg (German only): ▶
- Kompetenznetz Funktionelle Nanostrukturen (Competence Network for Functional Nanostructures) (German only): ▶
- Kompetenznetz für Materialien der Nanotechnologie (NanoMat Network for Nanotechnology Materials), Karlsruhe: ▶
- Kompetenzzentrum Ultrapräzise Oberflächenbearbeitung (Competence Center for Ultra-Precise Surface Treatment, CC UPOB) (German only): ▶
- NanoMikroWerkstoffe NRW Cluster (NanoMicro Materials Cluster North Rhine-Westphalia): ▶
- Nanosystems Initiative Munich (NIM): ▶
- Nanotechnology Cluster Bavaria: ▶
- Network for Nano- and Biotechnology, Saarbrücken: ▶
- Silicon Saxony, including the leading-edge cluster "Cool Saxony" ▶
- "Ultra-Thin Functional Films" Nanotechnology Center of Competence, Dresden: ▶

## Alliances for Innovation

- Innovation Alliance Carbon Nanotubes (Inno-CNT) ▶
- Innovation Alliance "Lithium Ion Batteries LIB 2015" ▶
- Innovation Alliance Molecular Imaging ▶
- Innovation Alliance Organic Electronics ▶
- Innovation Alliance Organic Photovoltaics (OPV) ▶

## Technology Transfer

- InnovationLab GmbH (iL): ▶
- Technology Transfer Initiative "Nanovalley:" ▶
- Technology Transfer at the Max Planck Society ▶
- Technology Transfer at the Leibniz Association: ▶

## Information and Knowledge Platforms

- German Nanotechnology Companies and Institutions Directory: ▶
- NanoMap, a portal for all of Germany's key nanotech players: ▶
- Portal for international R&D partnerships: ▶
- Portal for physics (German only): ▶
- Portal for photonics research (German only): ▶
- Portal on the German research and university scene: ▶

- [The VDI's portal for future-oriented technologies \(German only\): ▶](#)

## Public Institutions

- [German Federal Ministry of Research and Technology: ▶](#)
- ["nanoTruck" Treffpunkt Nanowelten \("nanoTruck" Meeting Place Nanoworlds\) information campaign ▶](#)

## Research and Development

- [Center for NanoScience \(CeNS\) at Ludwig-Maximilians Universität Munich: ▶](#)
- [Fraunhofer Nanotechnology Alliance: ▶](#)
- [German Research Foundation \(DFG\): ▶](#)
- [Institute for Nanotechnology at the Karlsruhe Institute for Technology \(KIT\) \(German only\): ▶](#)
- [Leibniz Network Nano ▶](#)
- [NanoEnergieTechnikZentrum \(NETZ\) for new materials in energy technology \(German only\): ▶](#)

## Risk Assessment

- [Center for Nanointegration Duisburg-Essen \(CENIDE\): ▶](#)
- [EU Nanosafety Cluster: ▶](#)
- [Europäische Forschungsinfrastruktur für Nanosicherheit \(European Research Infrastructure for Nanosafety\): ▶](#)
- [Federal Institute for Materials Research and Testing \(BAM\), Nanotechnology Working Group: ▶](#)
- [Kompetenzzentrum Nanoanalytik \(Competence Center for Nanoanalytics, CCN\), Hamburg: ▶](#)
- [Verband der Chemischen Industrie, \(Chemical Industry Association, VCI\), Chemicals Safety: ▶](#)
- [Wissensplattform Nanomaterialien \(Nanomaterials Knowledge Platform, DaNa\): ▶](#)

## Subsidies and Financing

- [Fraunhofer Venture: ▶](#)
- ["KMU-innovativ \(SME innovative, 'Nanochance'\)" subsidy program \(German only\): ▶](#)

## Nanotechnology in the EU

- [EU flagship pilot project on graphene and two-dimensional materials \(FET Graphene Flagship\): ▶](#)
- [Europäische Initiative zur Kommerzialisierung von Nanotechnologie \(European Initiative on the Commercialization of Nanotechnology\): ▶](#)
- [European Nanotechnology Gateway: ▶](#)

- [European Technology Platform for Sustainable Chemistry](#): ▶
- [Nanotechnology Homepage of the European Commission \(Cordis\)](#): ▶
- [Portal for Nanotechnology in the European Union](#): ▶

## Education, Training, and the Labor Market

- [The BMBF's sponsorship program for young academics, "NanoMatFutur" \(German only\)](#) ▶
- [Portal for nanotechnology education opportunities in Germany](#) ▶
- [The University of Duisburg-Essen's Nanotechnology Summer School](#) ▶



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