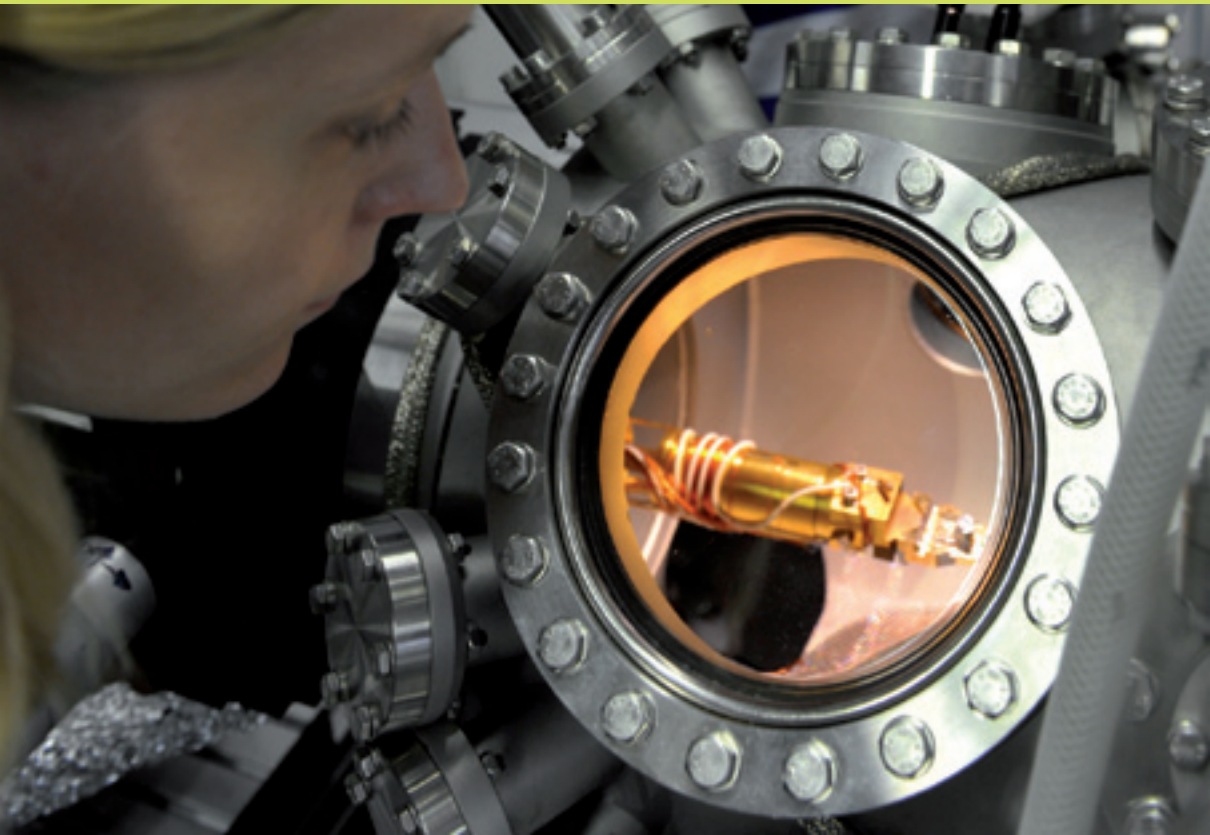
Freie Universität Berlin

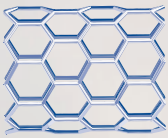
Focusing Research

The Focus Areas at Freie Universität Berlin

NanoScale



Focus Area NanoScale



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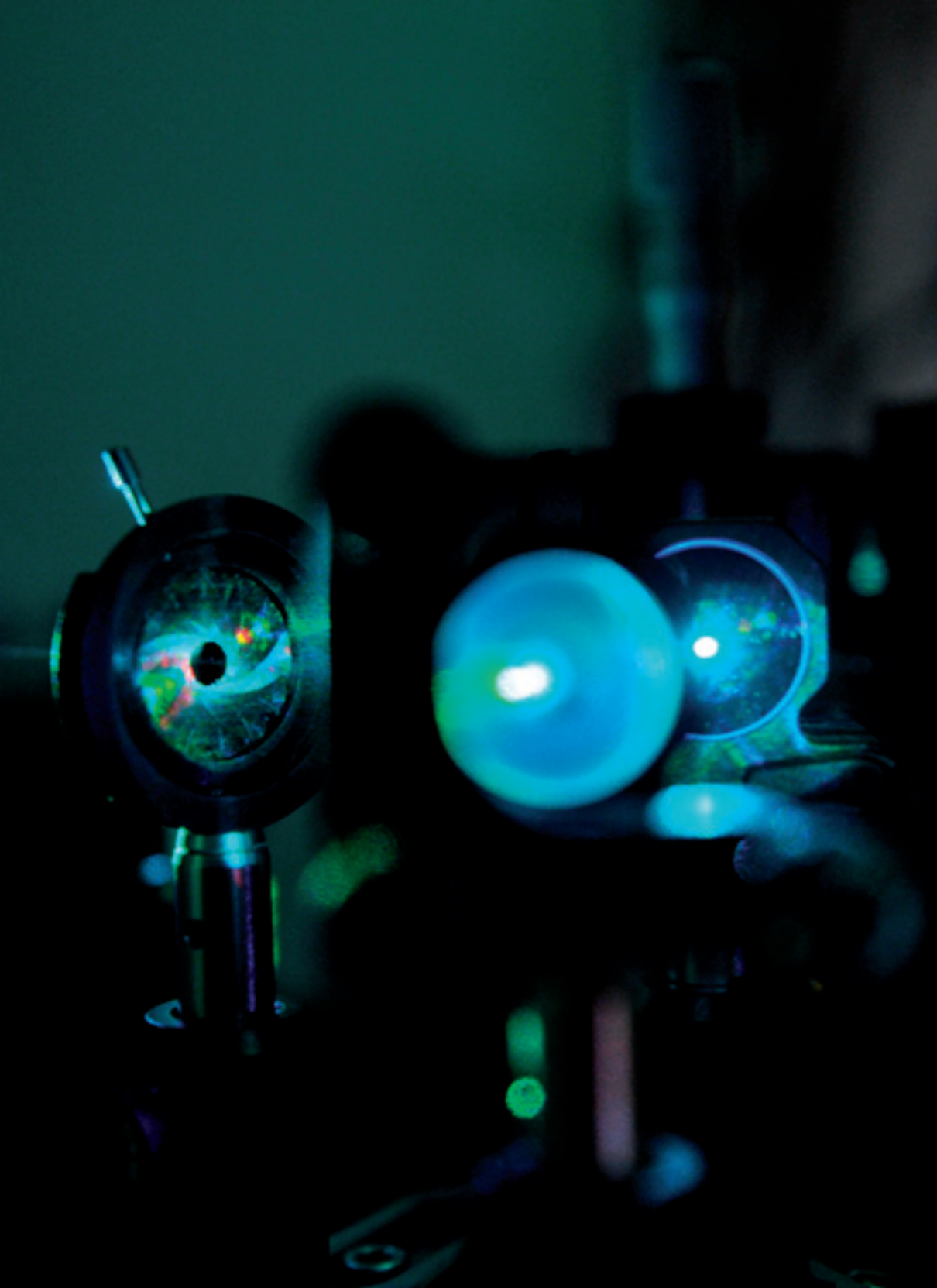


Focus Areas of Freie Universität Berlin

One special feature of the excellent, broad-based research performed at Freie Universität Berlin is the university's targeted formation of research alliances called Focus Areas.

NanoScale has been one of the Focus Areas of Freie Universität Berlin since 2009. Photo: B. Wannenmacher

Within the Focus Areas, scholars and scientists from different subjects, disciplines, and institutions at Freie Universität work together over a longer period on complex research topics related to subjects of great importance to society.

The Focus Areas help to strengthen the areas of emphasis within the university's research activities and further develop these areas in cooperation with social, political, and economic players.

The Focus Areas can be arranged differently, depending on the specific disciplines, the issues currently being studied, and the individuals involved. The options range from platforms fostering the discussion of ideas, with multifaceted courses and events – such as the Transregional Studies Salon series within the Center for Area Studies (CAS), one of the Focus Areas – to compact alliances dedicated to studying one key area of focus in current research activities, such as nanotechnology in the NanoScale Focus Area.

Goals of the Focus Areas

- Taking up research trends and exploring them in interdisciplinary alliances
- Pooling skills and expertise to answer current research questions
- Initiation of new projects and solicitation of funding

The Concept of the Focus Areas is Based on Three Key Principles

- Excellence in research across disciplines – for society, the political sphere, and the economy
- Networking and cooperative arrangements – regional, national, and worldwide
- Support for junior scholars and scientists – well structured, thorough, and comprehensive

Structure and Organization of the Focus Areas

The Focus Areas are platforms for the development of research ideas growing out of interdisciplinary and interdepartmental initiatives. They represent the very highest level of quality in research activities – guaranteed through ongoing evaluations. Each Focus Area has a spokesperson, who represents that Focus Area within the university and beyond.

The three strategic centers of Freie Universität provide crucial support to the Focus Areas:

- **The Center for Cluster Development (CCD)** – which will continue as the Center for Research Strategy (CRS) within the scope of the university's new institutional strategy – supports and monitors the initial development, management, and evolution of the Focus Areas.
- **The Center for International Cooperation (CIC)** supports the Focus Areas with regard to worldwide cooperative arrangements and international visibility.
- **Dahlem Research School (DRS)** offers advice and assistance for the Focus Areas with regard to measures in support of junior researchers.

Technology of the future: Nanostructures are tiny molecular units that can be addressed by research. Working on such structures requires highly specialized equipment, such as super-resolution microscopes with laser technology. Photo: B. Wannenmacher

The Henry Ford Building at Freie Universität, lecture hall building and conference center. Photo: B. Wannenmacher

NanoScale: an Overview

Nanostructures are small molecular units that researchers work with and the smallest units whose structure they can affect. Research on nanostructures yields groundbreaking possibilities for the use of nanoscale systems in medicine and materials science, along with the fields of electronics and optoelectronics.

"Functional molecular nanosystems will be critically important in the future – for miniaturization of electronics as well as for nanomedicine, which enables diagnostic and therapeutic options tailored precisely to an individual patient."

Professor Stephanie Reich, Director of the Focus Area

Photo: D. Ausserhofer

Within the *NanoScale* Focus Area, researchers from the disciplines of physics, chemistry, biology, and pharmacy work together to study the properties of nanostructures, how they arise from individual molecules, and how they can be used, all with a single goal: understanding the properties of nanostructures in order to develop components for individualized use in a variety of applications.

The nanometer scale ranges from individual molecules up to structures 100 nanometers in size. Nanostructures – ensembles of molecules – have dramatically different properties from those of materials that are observed macroscopically. The properties of nanoscale systems often vary widely in the nanometer range, and they in turn affect the properties of the materials composed of these systems.

Goals of NanoScale

- The interdisciplinary research performed within the NanoScale Focus Area is intended to yield a fundamental, detailed understanding of the origin and properties of nanometer-scale molecular systems and their interactions.
- Current research findings from NanoScale are intended to serve as a basis for developing new nanostructures, and thus new materials and molecular components – such as for logic circuits with the greatest possible level of miniaturization.
- Researchers at NanoScale hope their findings will open up new possibilities in diagnosis and medical treatment, aiding in development of new diagnostic tools, or, for instance, medications with fewer or less severe side effects.

Research at NanoScale

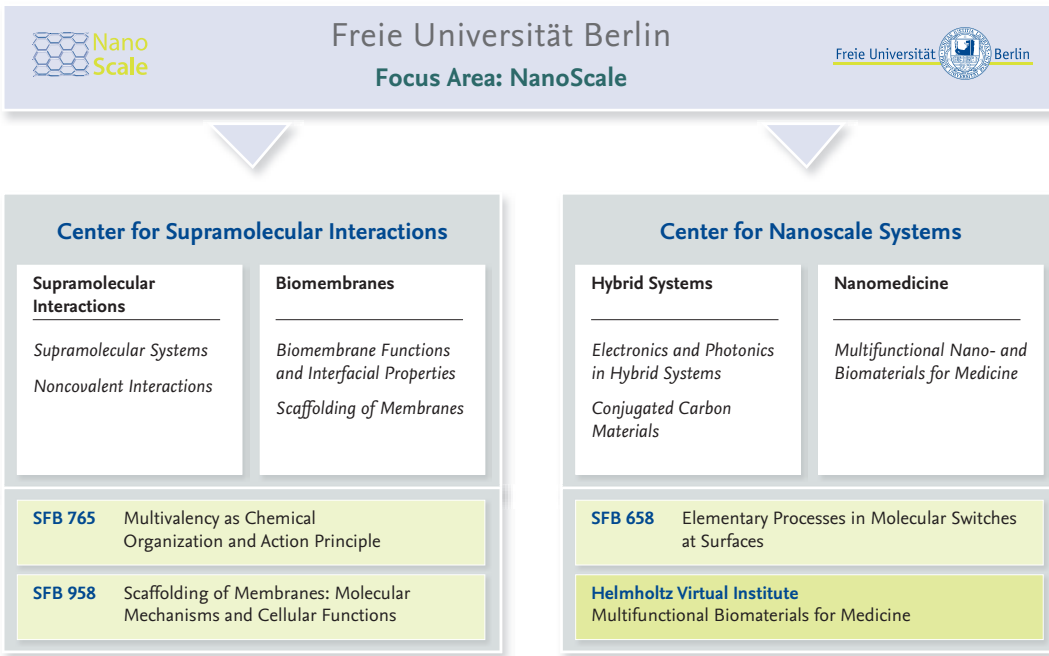
The main focus of NanoScale is performing groundbreaking interdisciplinary research on the material properties of nanoscale systems, with the objects of study ranging from nanotubes and nanoparticles to macromolecules and beyond, to peptides and proteins.
The research performed within the NanoScale Focus Area encompasses four central areas, all of which are closely interlinked:

- Hybrid systems
- Nanomedicine
- Supramolecular interactions
- Biological membranes

These four areas of focus are grouped together into two overarching research divisions: the Center for NanoScale Systems (CNS) and the Center for Supramolecular Interactions (CSI).

Backed by three collaborative research centers, which supply a solid experimental basis for NanoScale's research, and by one Helmholtz Virtual Institute, the members of this Focus Area work to develop new approaches to research beyond the boundaries of the disciplines involved.

A Helmholtz Virtual Institute brings together the key competences of one or more Helmholtz Centers with those of one or more universities to create a center of excellence of international standing. This serves to create a new quality of cooperation, strengthening scientific excellence and increasing international competitiveness. Other national or international partners may be involved as associated partners.



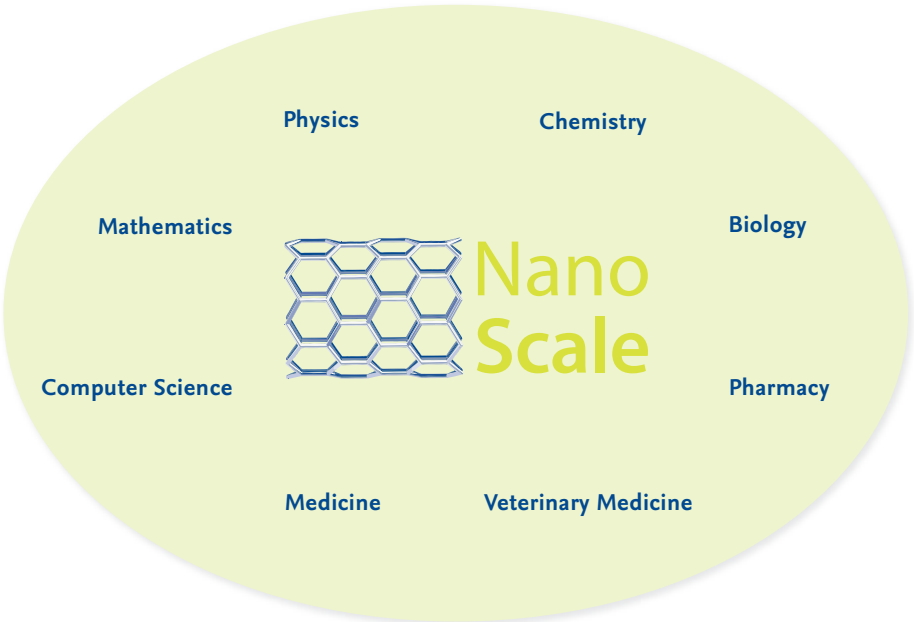
One nanometer (nm) is equal to one-millionth of a millimeter. Nanotechnology takes its name from this unit of length. One nanometer is to one meter like the diameter of a hazelnut is to the diameter of the Earth.

Photo: B. Wannenmacher

Disciplines within NanoScale

To be able to study the many different aspects of the nanoscale world, experts from various disciplines come together within the NanoScale Focus Area. The core subjects are physics, chemistry, biochemistry, and pharmacy. More than 140 scientists and their teams work together on individual interdisciplinary projects, projects specifically aimed at supporting junior scientists, and a number of large-scale research alliances.

Other departments are also involved: In the development of new treatments or diagnostic tools, for instance, the scientists within the Focus Area work together with researchers within the Department of Veterinary Medicine as well as Charité – Universitätsmedizin Berlin, the joint medical school of Humboldt-Universität zu Berlin and Freie Universität. Computer scientists and mathematicians provide support for the projects in the form of computer-assisted modeling and simulations. The researchers at the Focus Area also work together closely with first-class non-university research institutions, both on the research campus in Berlin's Dahlem district and elsewhere in the Berlin-Brandenburg region, a major hub of science and research activities.

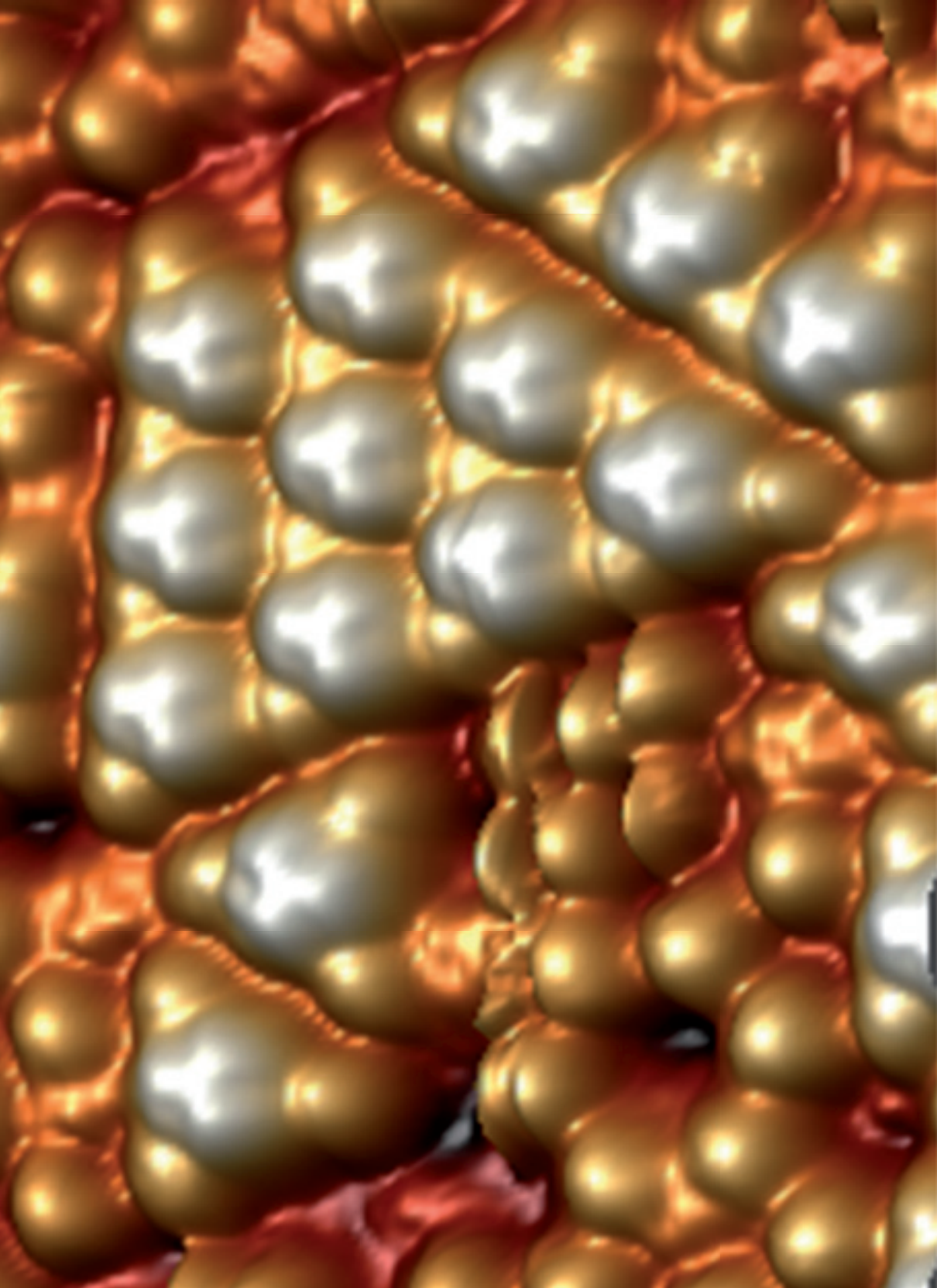


NanoScale: Facts and Figures

Term of funding	October 1, 2009 – December 31, 2014
Funding volume within institutional strategy	€ 3,610,000
Number of research groups involved	25
Scientists involved	148 (70 from Freie Universität)
of which, doctoral candidates	45
Freie Universität departments involved	Biology, Chemistry and Pharmacy; Physics Also: Charité – Universitätsmedizin Berlin; Veterinary Medicine; Mathematics and Computer Science
Regional cooperation partners	22
International cooperation partners	20

Within NanoScale, more than 140 scientists and their teams perform research on groundbreaking questions. Among them are chemists, physicists, biochemists, and biologists, along with medical researchers, veterinary medicine specialists, mathematicians, and computer scientists.

Photo: B. Wannenmacher



Junior Professor, Department of Physics

Dr. Katharina Franke, Junior Professor

"New issues are constantly arising from fundamental research. Although for every thousand ideas, there might only be one major breakthrough, each and every one of them is exciting at the outset. NanoScale makes it possible, without a time-consuming and labor-intensive application process, to gain support for junior research groups, integrate research fellows into teams, and finance small projects – which helps us pursue pending topics and develop new ideas. The increased levels of sharing and exchange of information within the department and at events organized by the Focus Area facilitate interdisciplinary work, with new, joint questions on nanosystems constantly arising as a result."

Junior Professor Katharina Franke

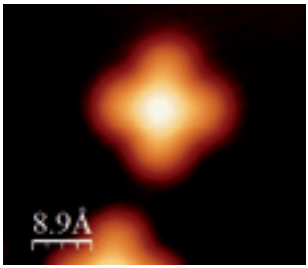
"Finding out new things" was always a thrill for Katharina Franke, who studied physics at the University of Kiel, in Germany, and Pennsylvania State University. She earned her doctorate at Freie Universität in 2003. Visiting positions and research projects took her to the University of Essen, the École Polytechnique Fédérale de Lausanne, in Switzerland, and the research institute RIKEN, in Tokyo. Since 2005, Katharina Franke has been at Freie Universität, performing research on electronic and magnetic properties of molecules at surfaces via scanning tunneling microscopy. The physical bases of electron transport through individual molecules and fundamentals of the magnetic interactions between molecules and metallic and superconducting surfaces could be important for future applications in electronic circuits and data storage. For her research, Franke was granted the Karl Scheel Prize by the Physikalische Gesellschaft zu Berlin in 2009. That same year, Katharina Franke, then 32 years old, was appointed a junior professor of experimental physics at Freie Universität. At NanoScale, she is in charge of projects in the fields of hybrid systems and supramolecular interactions (CSI).

Katharina Franke working with a scanning tunneling microscope. For her groundbreaking work on interactions between magnetic molecules and superconductors on the nanoscopic and mesoscopic scales, junior professor Franke received the 2012 Hertha Sponer Prize from the German Physical Society (Deutsche Physikalische Gesellschaft). Photos: B. Wannenmacher

Her goals: to develop outstanding ideas and share her enthusiasm and knowledge.

left: The self-organization of tetraphenyladamantane and fullerenes (C60) leads to the formation of triangular nanostructures, visualized using a scanning tunneling microscope at the Department of Physics. These nanostructures can be used to alter the surface conductivity of C60 molecules, also known popularly as "buckyballs."

Source: K. J. Franke, G. Schulze, J. I. Pascual



In the research area Hybrid Systems, researchers develop nanomaterials through innovative combinations of molecules. Shown are individual manganese phthalocyanine molecules on a lead surface, visualized by scanning tunneling microscopy.

Source: K. J. Franke, G. Schulze, J. I. Pascual

Current Fields of Research at NanoScale

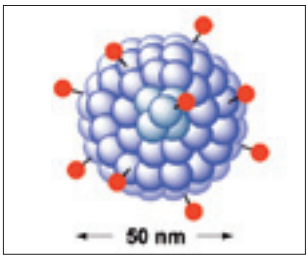
The research performed at NanoScale focuses on four areas: "Hybrid systems," "Nanomedicine," "Supramolecular interactions," and "Biomembranes."

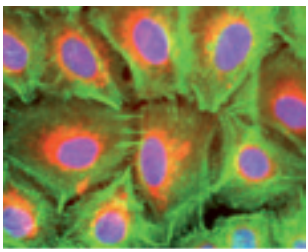
Within these four areas, scientists from the fields of chemistry, physics, biochemistry, pharmacy, and medicine work together to study molecules and molecular interactions of varying levels of complexity, using methods with the highest possible spatial and temporal resolution. Reaching unsurpassed precision, down to the tiniest detail, should allow researchers to generate existing and new materials and molecular processes under controlled conditions and affect them electronically, magnetically, or photonically (with light).

Hybrid Systems

Research performed in the field of hybrid systems is aimed at the interaction of individual molecular species and at examining and explaining their functional conditions.

Innovative ways of combining various molecules to form nanomaterials promise to help scientists uncover material properties that may be important in a number of different fields, such as in miniaturization of electronic circuits or production of customized surfaces. In particular, the changes in the properties of nanoparticles that are triggered by light pulses, magnetic fields, or electrical currents give scientists reason to hope for potential applications that have never before even been dreamed of – in computer technology and in materials science, where surface coatings are an active field of study.





Nanomedicine researchers develop functionalized carrier structures called nanocarriers to deliver medications directly to their pharmacological targets. This diagram shows a nanocarrier (blue) with red fluorescent groups (red). Below, the fluorescence image of cultivated lung cancer cells with a green-colored actin cytoskeleton is shown. The cells have taken up this kind of red fluorescent nanocarrier.

Source: R. Haag

Nanomedicine

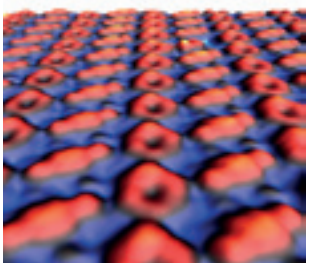
Research in nanomedicine is aimed at developing nanomaterials that can be used for both diagnostic and therapeutic purposes in the practice of medicine.

Because of their tiny scale, nanomaterials possess unique properties in their interaction with complex bodily fluids, cells, and tissues. Functionalized biocompatible carrier structures can therefore deliver medications with poor water solubility, or those that are difficult for the body to tolerate in high doses, directly to where they are needed. This helps to minimize side effects and enhance the efficacy of the medications. In regenerative therapy, researchers are focusing on developing functional materials to serve

as carrier materials for cells, for instance, or as biocompatible coatings for implants. Another area of emphasis is the development of diagnostic tools that are well tolerated by the body and have optimum properties.

Supramolecular Interactions

Research in the field of supramolecular interactions provides insight into the functions of macromolecules and the ways in which they interact. Within this field, researchers in the disciplines of chemistry, biochemistry, and biophysics study noncovalent forces – the weak interactions taking place between molecules. To achieve an understanding of these chemical and physical processes, noncovalent forces are studied in different environments, such as gas phases, solutions, or solids. Scientists hope to use this understanding to develop "supramolecular" structures with new abilities and generate new concepts for using these structures in various areas of people's lives.

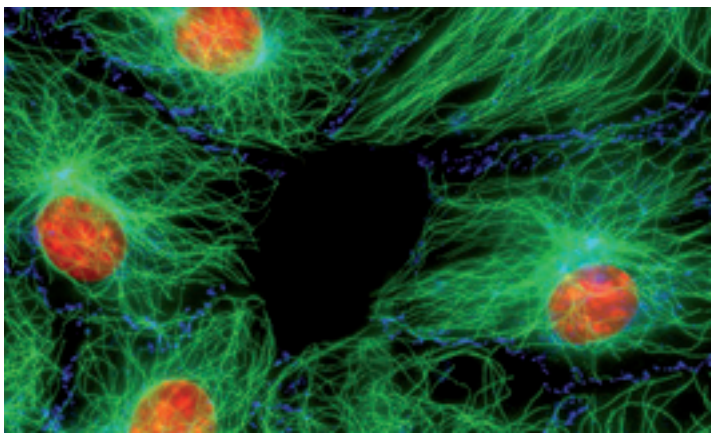


Molecular functions and how molecules interact with others are subjects of research area Supramolecular Interactions. Shown is a single layer of tetrathiafulvalene (TTF) and tetracyanoquinodimethane (TCNQ) molecules on a gold surface, as captured with a scanning tunneling microscope. Transferring one electron from TTF to TCNQ yields magnetic properties.

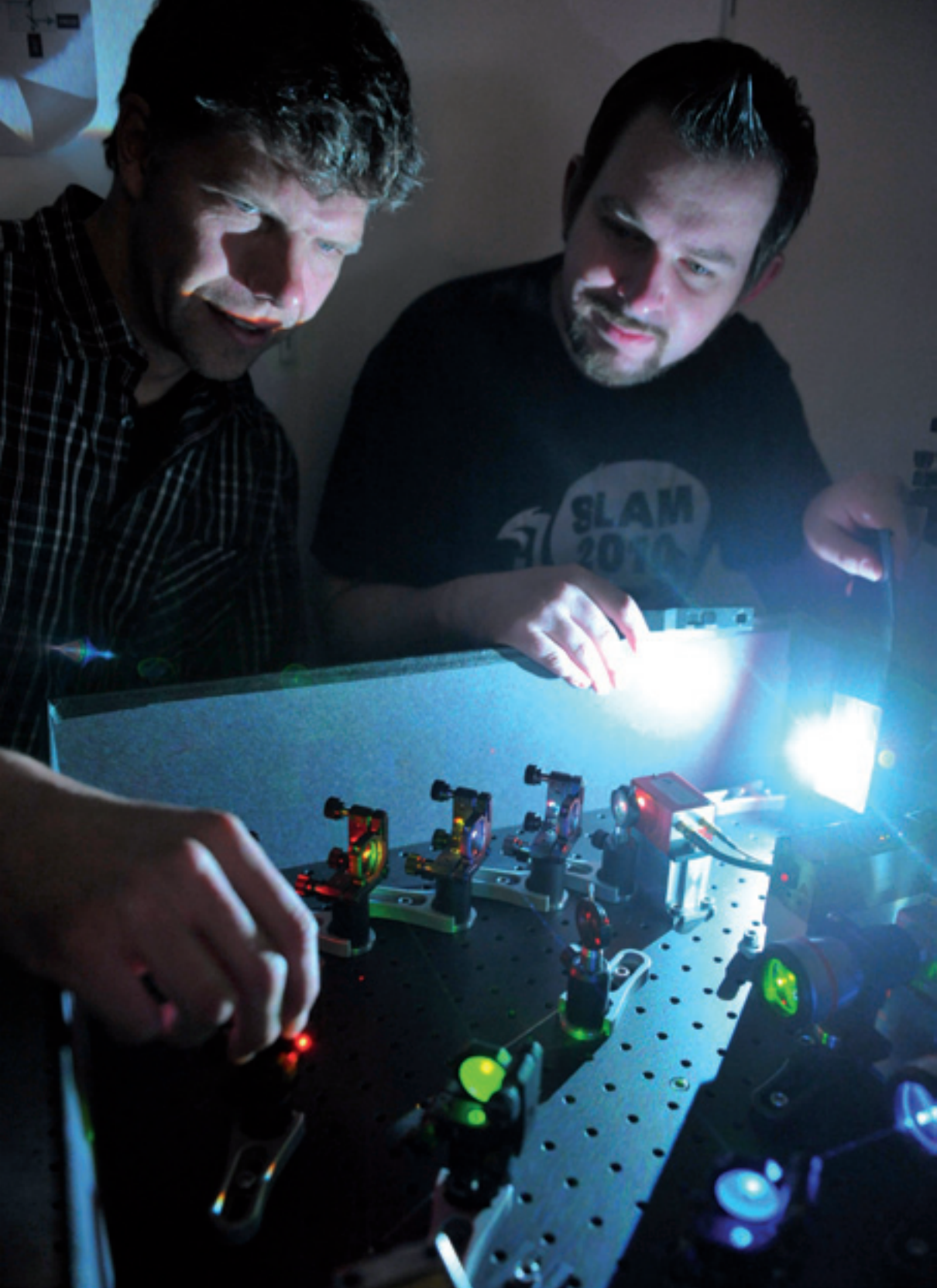
Source: I. Fernandez-Torrente K. Franke, J. I. Pascual

Biomembranes

The processes that take place within and at biological membranes are the center of the Focus Area's biomembrane research.
Biological membranes, comprising membrane lipids and proteins, encapsulate cells from their environments and separate aqueous compartments within cells. The proteins in these membranes establish the regular, controlled transport of molecules, energy, or information via the membrane. Protein scaffolds stabilize or alter the membrane structures. Cells utilize this to organize the processes that are vital to their survival and to assert themselves within their environments. The existing research on these processes is still inadequately understood at the molecular level. Identifying the principles at work will form the basis for new approaches in pharmacological treatment, or for production of functionalized artificial membranes inspired by biomembranes.



Researchers in the Biomembranes Research Area study the processes taking place within and on cells, using methods including high-resolution multi-color fluorescence microscopy. Three of the countless building blocks of connective-tissue cells have been colored with fluorescent markers: the DNA in the cell nucleus, approximately 10 µm in diameter (red), part of the cytoskeleton (green), and the cell-cell contacts (blue). Source: J. Schmoranzer


SLAM

Junior Research Group Leader, Institute of Chemistry and Biochemistry

Dr. Jan Schmoranzer

"I am fascinated by microscopy – the combination of living organisms and technology, and, of course, advances in technical possibilities: When you move beyond one limit in resolution, you never know what you'll see after that. Through NanoScale, research activities and publications on these topics are moving forward rapidly. There are a lot of specialists here who support each other. Flexible project financing also makes it possible to spark and pursue new research trends."

Dr. Jan Schmoranzer

Jan Schmoranzer originally studied physics at RWTH Aachen, earning his doctorate in cell biology in 2002 in a program involving studies at both Rockefeller University, in New York, and Freie Universität Berlin. Schmoranzer wants to make life in its smallest form visible; as a result, his area of emphasis is super-resolution microscopy, a technique that can be used to visualize the tiniest structures in cells, in multiple color channels, at a resolution of approximately 20 nanometers. This is important to fundamental research in molecular biology as it helps scientists better understand processes within the cells, at cell membranes and synapses. Schmoranzer, a Berlin native, began studying this topic at Rockefeller University (1996–2002) and continued at Columbia University (2002–2008) before returning to Berlin in 2008 to continue his research at the Molecular Cancer Research Institute at Charité – Universitätsmedizin Berlin. Since 2009, he has been in charge of the Super-Resolution Microscopy junior research group at NanoScale, where he is working on developing new methods in this field, with particular emphasis on cell biology and neurobiology.

His goal: to continue the development of super-resolution microscopy in multiple colors in order to unlock even more possible applications.

For researchers, manual dexterity is an indispensable skill: Jan Schmoranzer and his team put together the equipment for his research subject, super-resolution microscopy. Using laser light, scientists can visualize cell details that can be used for a range of different investigations in cell biology and biomedicine.

Photos: B. Wannenmacher

A Look at NanoScale's Research Activities

Dr. Christina Graf, professor of physical chemistry, heads a team developing nanoparticles designed to achieve higher contrast in images generated through magnetic resonance imaging (MRI). This could help visually identify metastases, for example, at even earlier stages than before.

Photo: B. Wannenmacher

The many research projects pursued at NanoScale Focus Area are all marked by interdisciplinary cooperation among scientists. For a closer look at one example of this approach in action and the opportunities arising from collaborative research, we turn to one project of the many under way within the Focus Area.

Highlighting Contrasts

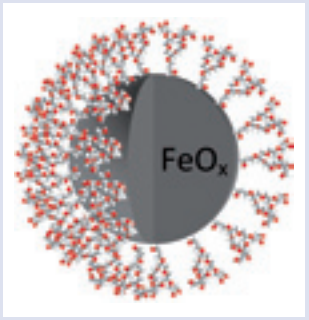
Being able to look inside human or animal bodies is an idea that has always fascinated scientists. X-ray radiation was first used to this end in 1895, a method later joined by computed tomography and X-ray computed tomography. With magnetic resonance imaging (MRI), first introduced in the 1970s, it is possible to depict the structure and function of tissue and organs without exposing them to X-ray radiation, aiding in detection of pathological tissue changes.

These images become clearer through the use of contrast agents which may be ingested by patients or injected. These agents frequently consist of magnetic iron oxide particles. Certain cells, such as those in the liver, can take up these particles, which causes them to take on a darker appearance in the images. Metastases, on the other hand, do not absorb them, so they have a telltale light-colored appearance even in the very early stages.

The quality and composition of the contrast media used are crucial in determining the quality of the images – and thereby the early detection of diseases. Christina Graf and Eckart Rühl, both professors in physical chemistry, are studying how these agents can be prepared with a higher selectivity, and with better physical tolerability, in the future as part of the NanoScale project entitled "Development of Innovative Selective Iron Oxide Nanoparticles for MRI" (*Entwicklung neuartiger selektiver Eisenoxidnanopartikel für die MRT*), which they are pursuing with cooperation partners from various disciplines and institutions.

"Our goal is to produce contrast agents that have even higher magnetic efficacy in lower quantities, thereby achieving even more marked contrast," says Graf, a physical chemistry researcher at the Institute of Chemistry and Biochemistry of Freie Universität. The researchers also hope to develop a new substance that can target areas where disease is present within the body and can be resorbed more rapidly by the organism.

To that end, Graf and her team are producing iron oxide nanoparticles that they hope will help detect inflammatory heart disease earlier, among other uses. To ensure that these particles result in high contrast in the



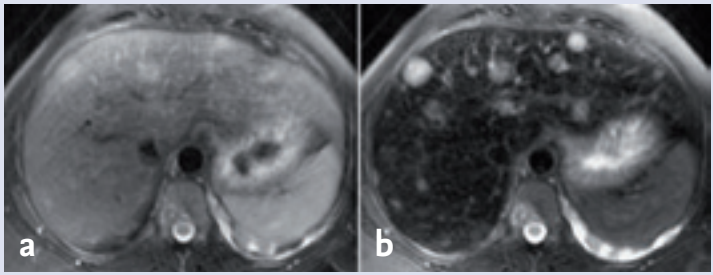
Model of an iron oxide nanoparticle with a dendritic polymer coating. The inorganic core (gray) is surrounded by stabilizing organic molecules (multivalent ligands). Each ligand has multiple binding sites; they are produced by researchers working in organic chemistry. Source: R. Haag

MRI images, the inorganic core of the particles is optimized. The core of each particle is surrounded with stabilizing organic molecules called ligands. These molecules are supposed to keep the particles from clumping together in the bloodstream and ensure that they accumulate selectively, only targeting inflamed tissue within the body. Specific ligands, termed "multivalent" ligands for their multiple binding sites, are used to achieve this. They are produced by a team headed by Rainer Haag, professor of organic and macromolecular chemistry at the Institute of Chemistry and Biochemistry.

At Charité – Universitätsmedizin Berlin, the joint medical school operated by Freie Universität Berlin and Humboldt-Universität zu Berlin, specialized physicians and medical researchers are involved in the NanoScale project. Matthias Taupitz, a radiology professor, heads a team that develops new substances and tests their use in MRI. Ursula Rauch-Kröhnert, a cardiologist and a professor at the Center for Cardiovascular Diseases, Benjamin Franklin Campus, specializes in cardiomyopathies, or diseases of the heart muscle. She is utilizing the newly developed substances in animal trials.

The risks involved in using nanoparticles in human or animal bodies have not yet been clarified sufficiently. This issue is another area of emphasis in nanoparticle research, drawing attention from veterinary medicine specialists at Freie Universität. The research group headed by Achim Gruber, a professor of the Institute of Veterinary Pathology, for instance, is using radio probes to study where and how long multivalent nanoparticles remain in animal models.

To characterize the structure and magnetic properties of the nanoparticles, Graf's team utilizes synchrotron radiation, an especially intensive form of x-ray radiation. These experiments are carried out at the electron storage ring BESSY, at the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB). Photo: HZB



This image of an MRI scan shows a cross-section of a patient's body. The image slice passes through the liver. Liver metastases are shown without (a) and with (b) iron oxide nanoparticles. The particles darken the healthy liver tissue in the image, so metastases stand out more and additional small ones are easier to see. Source: M. Taupitz, Charité – Universitätsmedizin Berlin

Regional, National, and Global Networks

The Focus Area is a platform for regional and international interdisciplinary collaborative research projects. NanoScale maintains an extensive network within the Berlin-Brandenburg region, a major hub of science and research activities.

Chemists generate the nanomaterials required for the other disciplines represented within NanoScale. Physicists study their properties experimentally and describe them in theoretical terms. Photo: B. Wannenmacher

The research emphases established within NanoScale, and the cooperative arrangements associated with them, involve a level of density found nowhere else in Germany. Particular highlights include the research performed on carbon nanostructures, photosynthesis, as well as the findings generated by research on biochemistry and medicine within the neurosciences.
One of the goals of NanoScale is to strengthen cooperation among outstanding research groups within the disciplines of biochemistry, chemistry, pharmacy, physics, and medicine. With this aim in mind, the Focus Area engages in a broad-based and extensive variety of research networks within the region, throughout Germany, and internationally.

Regional Cooperation Partners

About 70 leaders of individual research groups at Freie Universität work within NanoScale, together with the same number of colleagues from other universities and from outstanding non-university research institutions within the Berlin-Brandenburg region, a major hub of science and research activities, all of them examining groundbreaking research issues. Researchers and scientists from the Helmholtz Association, the Max Planck Society, and the Fraunhofer Society, along with their work, are all firmly integrated into the NanoScale network. Thus, when it comes to characterizing nanostructures, researchers can make use of the excellent infrastructure present in the region, with its large-scale research equipment – such as the BESSY-II electron storage ring, the BER-II neutron research reactor – and equipment used in laser and resonance spectroscopy along with tomography-based methods.
Based on the cooperative arrangements put in place, the researchers apply for external funding for interdisciplinary research projects. By coordinating collaborative research project initiatives and financing bridge projects, NanoScale provides important start-up assistance during the preparatory stages of new projects and cooperative initiatives. Thus this Focus Area forms an important basis for soliciting external funding.

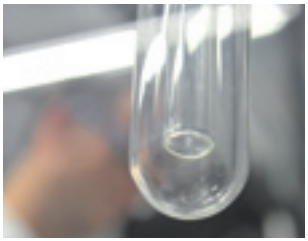
Medical researchers rely on these kinds of materials to craft implants, generate top-quality X-ray images, or deliver medications precisely to their targets. Photo: BSRT

NanoScale in the Public Eye

Scientists from NanoScale present current issues and recent findings from their research during public events and roundtable discussions held in the Berlin-Brandenburg region, a major hub of research activities. In 2011, these events included a series of talks at Urania Berlin, an event and science center.

Cooperation partners of NanoScale in the Berlin-Brandenburg region, home to many academic institutions

1 Technische Universität Berlin
2 Humboldt-Universität zu Berlin
3 University of Potsdam
4 German Rheumatism Research Centre (DRFZ)
5 Fraunhofer Institute for Applied Polymer Research (IAP)
6 Fritz Haber Institute of the Max Planck Society (FHI)
7 Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)
8 Helmholtz-Zentrum Geesthacht (HZG), Centre for Biomaterial Development, Teltow
9 Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin (MBI)
10 Max Delbrück Center for Molecular Medicine (MDC)
11 Max Planck Institute for Infection Biology (MPIIB), Berlin-Mitte
12 Max Planck Institute for Infection Biology (MPIIB), Berlin-Marienfelde
13 Max Planck Institute of Colloids and Interfaces (MPIKG)
14 Leibniz-Institut für Molekulare Pharmakologie, Berlin (FMP)
15 Paul Drude Institute for Solid State Electronics, Berlin (PDI)
16 Zuse Institute Berlin (ZIB)
17 Physikalisch-Technische Bundesanstalt (PTB)
18 Federal Institute for Materials Research and Testing (BAM)
19 Federal Institute for Risk Assessment (BfR)
20 German Institute of Human Nutrition Potsdam-Rehbrücke (DIfE)



Findings from research performed at NanoScale are later used by materials scientists, who employ them to develop materials and surfaces with defined properties, such as waterproof surface coatings made from nanoparticles. Photo: B. Wannenmacher

Cooperation Partners throughout Germany

The researchers at NanoScale maintain extensive cooperative relationships with research groups in other regions of the country. Especially close ties exist with the Helmholtz-Zentrum Geesthacht (HZG) and the Helmholtz-Zentrum Berlin (HZB), a relationship that has led to joint research alliances such as the Helmholtz Virtual Institute on Multifunctional Biomaterials in Medicine.

Within the scope of the "Key Technologies" research focus of the Helmholtz Association, extensive cooperative agreements have been initiated with the Karlsruhe Institute of Technology (KIT), the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), and the GSI Helmholtz-Zentrum für Schwerionenforschung, in Darmstadt.

NanoScale also works closely with the University of Freiburg and its excellence cluster "BIOSS – Centre for Biological Signalling Studies" in the development and evaluation of biomaterials.

Worldwide Cooperation Partners

NanoScale works together with about 20 institutions in Europe, Asia, North America, and Australia. As a result, the Focus Area maintains extensive and varied networks with centers of expertise around the world, such as the Nanoscience Center at the University of Hyderabad, India, the Wyss Institute at Harvard University, and the Center for NanoBio Integration (CNBI) at the University of Tokyo.

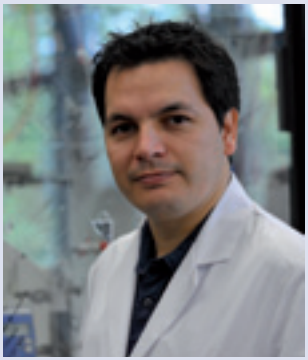
Researchers at NanoScale leverage the outstanding research infrastructure present in the Berlin-Brandenburg region, which is home to many academic institutions, along with the Focus Area's close partnerships with more than 20 institutions. NanoScale also works with experts in Europe, Asia, the Americas, and Australia.

Photo: B. Wannenmacher

Junior Research Group Leader, Institute of Chemistry and Biochemistry

Dr. Marcelo Calderón

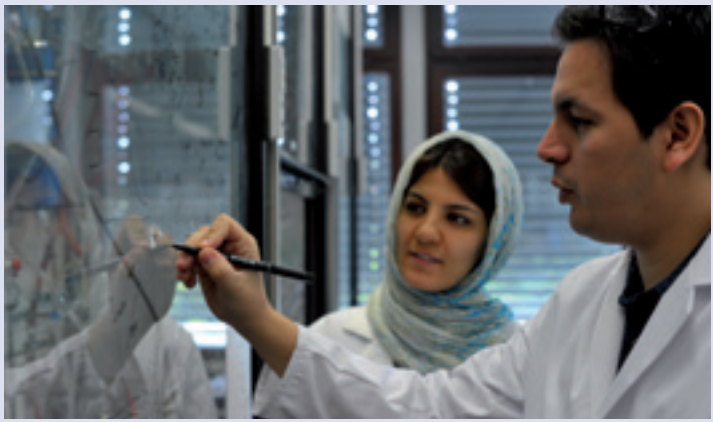
"Research activities here are extremely well organized and the teams are put together well. We complement each other's skills and abilities and can share equipment and facilities. The financing options at NanoScale offer postdocs a certain level of autonomy: I can pursue my areas of focus and develop my own research group, and as a researcher from a non-European country, I gain entry into the academic system in Germany in the process. Plus, Berlin is just a great city to do research and live in."



Dr. Marcelo Calderón

Marcelo Calderón studied chemistry at the Universidad Nacional de Córdoba, Argentina, earning his doctorate in organic chemistry in 2007. He first came to Germany in 2006, as a research fellow – during the FIFA World Cup. The atmosphere in Berlin at the time greatly impressed Calderón, a native of Argentina – along with the research activities under way at Freie Universität, where he has been involved in research on polymers for biomedical applications since 2007. At NanoScale, Marcelo Calderón has been in charge of a junior research group studying the development of nanotransport systems since 2010. Depending on their structure, these systems offer a variety of potential uses – improving the tolerability of medications, for instance, or in treatment of tumor cells. Cooperative projects have taken Calderón to a number of institutions in North and South America, Asia, and Europe. He received the Arthur K. Doolittle Award from the American Chemical Society in 2010.

His goals: a junior professorship and breaking new ground in nanomedicine.



Chemist Marcelo Calderón and his team study nanotransport systems, specifically polymers and dendrimers. These chemical compounds made up of chain molecules and highly branched molecules can be used in biomedical applications.

Photos: B. Wannenmacher

International Projects on Global Issues in Nanotechnology

The NanoScale Focus Area, founded in 2009, aims to raise its international profile as a multidisciplinary research center at Freie Universität Berlin.

NanoScale contributes to answering global questions. To this end, researchers at the Focus Area work with experts all over the world. Each year, many of these partners come to the research campus, located in Berlin's Dahlem district, as guests.

Photo: B. Wannenmacher

The global networks of NanoScale allow this Focus Area to engage in research projects that transcend national borders. In this way, NanoScale contributes to finding the answers to global issues. Researchers from all over the world regularly visit the Focus Area as guests, giving talks and presentations, engaging in cooperative projects, or participating in one of the NanoScale research groups.

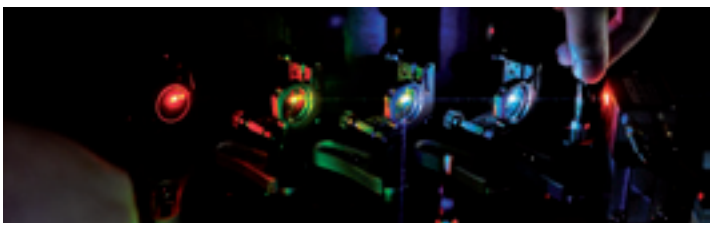
Professor Takuzo Aida (University of Tokyo), recipient of the Alexander von Humboldt Research Award for 2011, plans to do research on nanohydrogels at NanoScale. These gels are highly important to research in the fields of supramolecular interactions and nanomedicine – for forming gels that tolerate mechanical strain and have high water content for hydrating the skin, for instance, or to administer drugs via the skin.

Multifunctional biomaterials for use in medicine are the focus of the cooperative research initiative in place with the Helmholtz Virtual Institute on Multifunctional Biomaterials in Medicine and the team headed by Professor Kazunori Kataoka, director of the Center for NanoBio Integration (CNBI) at the University of Tokyo.

The international network of NanoScale also benefits junior scientists. For example, NanoScale and the research group headed by Professor David Weitz, director of the Wyss Institute at Harvard University, maintain an extensive exchange of doctoral students and postdocs.

International Conferences

To foster exchange of ideas and information at the international level, NanoScale is involved in organizing international conferences and conventions and regularly holds lecture series with celebrated international guest speakers.



NanoScale regularly organizes events aimed at sharing information and ideas on current questions in nanotechnology. Some events are aimed at a specialized audience, while others are intended for the public at large.

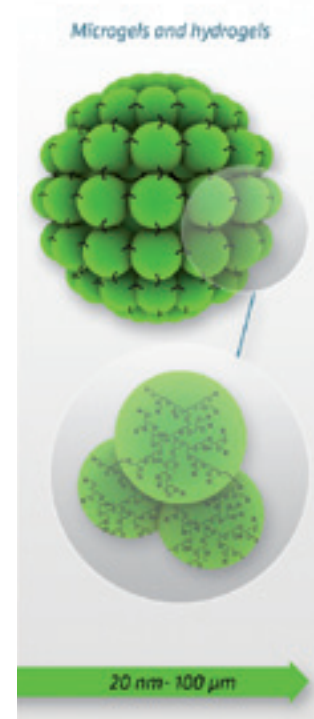
Photo: B. Wannenmacher

Trilateral Symposium on "NanoBio Integration, Berlin, 2010"
At this symposium, which was organized by NanoScale at the Institute of Chemistry and Biochemistry of Freie Universität, 80 scientists discussed issues and concepts involved in nanomedicine. The goal of the event was to develop innovative approaches to the use of nanomaterials and biomaterials in medicine and to intensify the scientific exchange of information among the NanoScale Focus Area, the Center for NanoBio Integration at the University of Tokyo, and the Wyss Institute at Harvard University.

Polydays 2010: "Polymers in Biomedicine and Electronics"
The biannual Polydays event, organized by the Macromolecular Chemistry research group of the German Chemical Society (GDCh), focuses on polymer structures. The key topic of the Polydays 2010, which was co-organized by the NanoScale Focus Area at Freie Universität, was the design and synthesis of functional polymers for potential uses in nanomedicine and electronics.

SFB 658 Symposium on "Transport through Molecules"
This event focused on fundamental phenomena and concepts relating to transport of various entities, such as charges, through individual molecules. The event, which took place in the general area of hybrid systems, involved discussions with European cooperation partners from Budapest University of Technology and Economics (BME), in Hungary, Leiden University and Delft University of Technology (TU Delft), in the Netherlands, and the Technical University of Denmark (DTU), in Copenhagen, with talks centering on the properties of nanostructures under the influence of electricity, light, and magnetic fields.

SFB 765 Symposium on "Multivalency as Organization and Action Principle"
The focus of this first international symposium was on achieving a fundamental understanding of principles of multivalency in biology, chemistry, and biophysics and exploring their applications. With the involvement of scientists from the Massachusetts Institute of Technology (MIT), LMU Munich, and the University of Göttingen, along with more than 50 doctoral students, phenomena in multivalency were discussed.



Dendrimers (from the Greek dendron, "tree") are chemical compounds whose structure starts from a single core and branches outward like the branches of a tree. This image depicts a model of dendritic polyglycerols. Dendritic polysulfates can be used to diagnose and treat inflammatory reactions. These are subjects of research for DFG collaborative research center (SFB) 765, "Multivalency as a Chemical Organisation and Action Principle," which received approval for another four years of funding, totaling eight million euros, from the German Research Foundation (DFG) in 2011.
Source: M. Calderon, M. A. Quadir, S. K. Sharma, R. Haag

Support for Students and Junior Researchers at NanoScale

The extensive cooperation between the NanoScale Focus Area and the departments involved results in comprehensive education for students and junior researchers. Structured doctoral programs with extensive supervision and support and the opportunity to participate in interdisciplinary networks open up a whole range of possibilities for students and researchers.

At NanoScale, students, doctoral candidates, and postdocs receive insight into current research right from the start. The excellent support that Freie Universität provides to junior scholars and scientists offers them outstanding prospects. Photo: B. Wannenmacher

Studying

NanoScale includes current research topics in the traditional subjects studied within the participating disciplines.

Right from the start, researchers at NanoScale provide students with insight into current developments in research. Students are also integrated into the networks maintained by NanoScale through their cooperation in projects within the Focus Area.

Bachelor's Degree Programs

- Biology
- Biochemistry
- Chemistry
- Bioinformatics
- Pharmacy (State Exam)
- Physics

Master's Degree Programs

- Chemistry
- Molecular and Cell Biology
- Neurobiology and Behaviour
- Physics
- Polymer Science

Doctoral Studies

Doctoral Programs

The doctoral programs in Biomedical Sciences and Molecular Science were established in 2008 as part of Dahlem Research School (DRS) at Freie Universität Berlin. The goal is to provide a structured program for doctoral candidates, including the disciplines relevant to the research performed within the NanoScale Focus Area.

- Biomedical Sciences

The doctoral program in Biomedical Sciences is dedicated to the fundamental and applied life sciences. From studying individual molecules of great medical importance to illuminating the mechanisms used by infectious diseases that are communicable to humans and beyond, to pro-

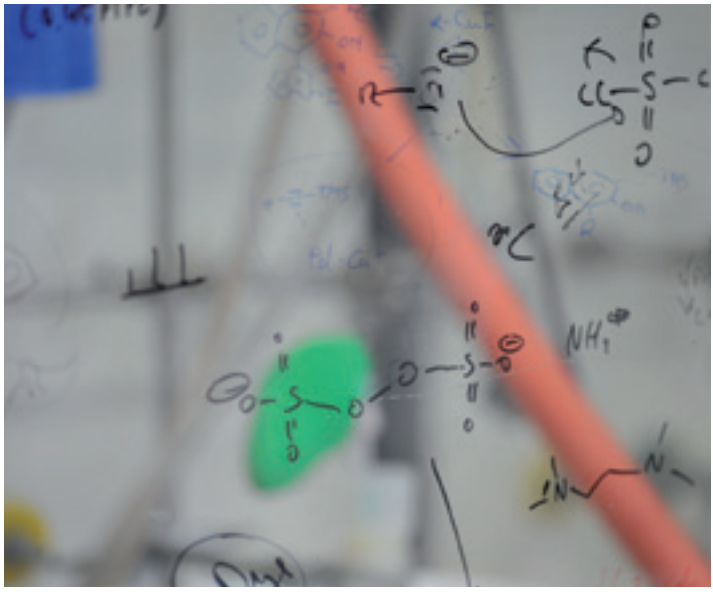
jects with heavy emphasis on real-world practice in patient care and food science, this program covers a broad spectrum of topics in the areas of biology, chemistry, pharmacy, and veterinary medicine.

▸ Molecular Science

The doctoral program in Molecular Science is a joint initiative sparked by the Department of Physics and the Department of Biology, Chemistry and Pharmacy. The research topics range from studying small molecules to biomolecules in complex environments. Major areas of focus for this English-language program include nanoscale functional materials, biocommunication, and simulation of molecular processes.

Both doctoral programs are integrated into the structure of Dahlem Research School (DRS) at Freie Universität Berlin, with their education programs and additional course options. They also include the teaching of transferable skills, which includes knowledge transfer, scientific management, and foreign language skills. For example, students can take seminars on scientific writing and publishing, statistics workshops, or training sessions on applying for jobs.

Both programs offer their doctoral candidates not only solid subject-specific knowledge based on current research, but also specific support



Promising connections: Junior scientists are integrated into NanoScale's regional, national, and global networks right from the start.

Photo: B. Wannenmacher

Dahlem Research School (DRS) launched a special funding program for international postdocs in 2011.

Photo: DRS

and extensive supervision. While completing the doctorate, candidates also learn the skills they need for later positions of leadership in academia and the sciences.

Each SFB has an integrated Research Training Group

All of the collaborative research centers (SFBs) involved in NanoScale have their own integrated research training groups for structured training of doctoral candidates. Each research training group is in turn affiliated with one of the two graduate programs, Molecular Science or Biomedical Sciences, within DRS.

Research and Financing

About one-third of the 70 scientists at NanoScale who are affiliated with Freie Universität are junior scientists, and there are just as many women present in the Focus Area as men. The various aid opportunities offered within the Focus Area allow them to start their own projects, or they can receive support in writing individual funding applications or doing preparatory work for joint applications. Others receive aid and support as subproject managers within a collaborative research center or as the leaders of junior research groups.

Pointing the way forward: the POINT support program in the Focus Areas

In 2011, Dahlem Research School (DRS) launched a special aid program for postdocs: Postdoc International, or POINT. Each year, the program makes it possible for five outstanding researchers from other countries to spend a total of twelve months pursuing research projects in the Focus Areas at Freie Universität. Each POINT fellow's objective is to get his or her project ready to apply for aid and then to raise funding for the project.

The fellows are integrated into the research networks existing within the Focus Areas. They participate in an individualized weeklong orientation program and in the DRS qualification program and receive access to the mentoring and career development programs offered by DRS.

For further information, please contact fellowship-drs@fu-berlin.de

CNS Fellow

Dr. Jingcheng Li

"The research performed here is very multifaceted, and it is also simply a lot of fun. The working conditions and atmosphere are excellent, and everyone gets along in English as a matter of course. Because of the outstanding culture of cooperation, we reach good results faster. All of this means I really enjoy working at NanoScale and at Freie Universität."

Dr. Jingcheng Li

Jingcheng Li studied physics at the University of Science and Technology of China in Hefei, earning his doctorate in 2010. While he was writing his dissertation, he visited Germany for the first time, working at the Max Planck Institute for Solid State Research, in Stuttgart. Since 2004, Li has been studying research issues in nanophysics, a field that brought him to Freie Universität in 2010. Here, he is a fellow in Hybrid Systems at NanoScale, devoting his energies to fundamental research on electron transport through individual molecules: He studies the emission of light from molecular contacts under an electrical current in order to determine certain properties of the molecule being examined. The results can be used to conclude, for example, how resistant to electricity materials composed of such molecules are.

His goal: to continue to perform good research as part of a team.

Dr. Jincheng Li has been engaging in research on nanophysics since 2004. After a period of research at the Max Planck Institute for Solid State Research, Li came from the University of Science and Technology of China (USTC) to Freie Universität Berlin in 2010 for a fellowship at NanoScale.

Photos: B. Wannenmacher

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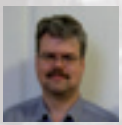

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