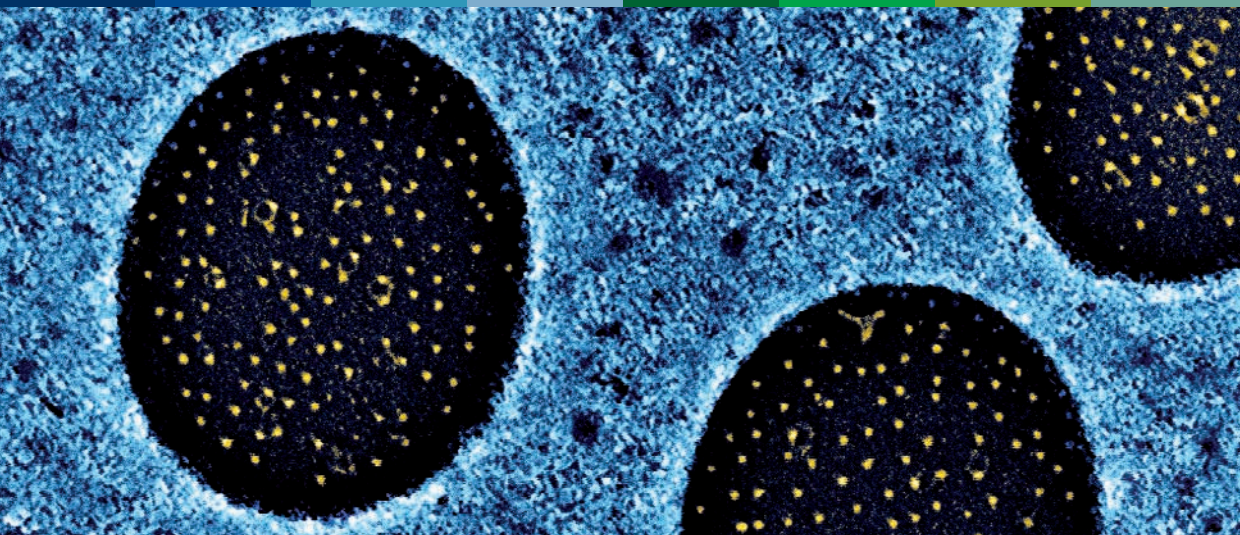


Nanotechnology

Physics, Chemistry, and Biology of Functional Nanostructures

Landesstiftung Baden-Württemberg

Th. Schimmel · H. v. Löhneysen · Ch. Obermair · M. Barczewski




LANDESSTIFTUNG
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Cover: Taylor-made surface for the cell regulation: Hierarchically arranged gold nano particles (diameter about 10 nm) produced by self-organization in thin polymer films.

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M. Schwieder, J. Spatz; MPI für Metallforschung Stuttgart

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Results of the first research programme Kompetenznetz "Funktionelle Nanostrukturen" (Competence Network on Functional Nanostructures)

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**Results of the first research programme
Kompetenznetz “Funktionelle Nanostrukturen”
(Competence Network on Functional Nanostructures)**

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Karlsruhe, May 2008

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Preface

Nanotechnology has to be considered one of the most important key technologies of the 21st century. Versatile activities in research and development have yielded results that quickly became taken for granted in our daily lives. They cover a wide variety of uses such as in electronic gadgets like hard disks, memory and microprocessors for computers, in soil-resisting surfaces used in bathroom facilities or automotive lacquer coatings, in new applications in environmental technology and disposal of waste as well as in the health sector.

Considering nanotechnology, it is of particular importance that those uses require an interdisciplinary approach. To that account the Landesstiftung Baden-Württemberg started already in 2003 promoting research programmes for the Kompetenznetz "Funktionelle Nanostrukturen" (competence network on functional nanostructures) and supported research facilities in Karlsruhe, Konstanz, Stuttgart, Ulm, Freiburg, and Tübingen. All in all, scientists from miscellaneous fields of these facilities have worked on 20 distinct topics.

In addition to the exceptionally outstanding quality of the research results and the new project ideas the Kompetenznetz excels in strong cross-linking, its exemplary support for junior researchers and in distinguished interdisciplinary collaboration generally extending over several research facilities. Another distinctive feature of the network and the research projects is the scientists' constant focus on implementation and productive use from the very beginning based on fundamental research.

The success of the network stems from both its speakers, Prof. Dr. Thomas Schimmel and Prof. Dr. Hilbert von Löhneysen, from the efficient coordination office and from the consistently excellent scientists in the individual research projects.

Due to this success and due to the importance for scientific as well as economic purposes in Baden-Württemberg the Landesstiftung decided to issue an invitation for tender for a second and furthermore for a third time, each time emphasizing a slightly different selection of topics.

In the given publication we'd like to provide an inspiring glimpse into the results of the first research programme funded by the Landesstiftung Baden-Württemberg.



Herbert Moser
Executive Director



Rudi Beer
Head of Department Science
and Research

A handwritten signature in black ink, appearing to read 'Herbert Moser'.

Herbert Moser

A handwritten signature in black ink, appearing to read 'Rudi Beer'.

Rudi Beer

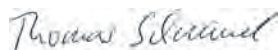
Preface of the Spokespersons of the Research Network

The book presented here gives a view into current topics in the field of nanotechnology. Its three parts "Nanodevices", "Functional Nanostructured Surfaces", and "Nanoparticles and Nanomaterials" represent three key areas of nanotechnology. They give an overview of the current state of research in major fields in the area of functional nanostructures.

We would like to sincerely thank the Landesstiftung Baden-Württemberg and the Ministry of Science, Research and the Arts, Baden-Württemberg for their generous support, also on behalf of the participating scientists of the research network. This support has been the basis for the numerous cooperative scientific projects. Without it, achieving the results presented here would have been impossible.

We cordially thank Mr. Herbert Moser and Mr. Rudi Beer as well as Ms. Irene Purschke and Dr. Simone Plahuta of the Landesstiftung Baden-Württemberg; Dr. Heribert Knorr and Dr. Renate Fischer of the Ministry of Science, Research, and the Arts, Baden-Württemberg; Dr. Joachim Fröhlingsdorf of the VDI Technologiezentrum GmbH as project executing organization; Dr. Matthias Barczewski and Dr. Christian Obermair of the administrative office of the network.

Karlsruhe, April 2, 2008



Thomas Schimmel



Hilbert v. Löhneysen



Thomas Schimmel



Hilbert v. Löhneysen

Introduction

Nanotechnology is considered one of the key technologies of the 21st century. Increasingly small structures are gaining technological and economic importance. The scope of applications ranges from car paints and catalysts to high-performance materials; from medical applications to data storage devices and micro- and nanoelectronics, to mention but a few examples.

Rapid progress in nanotechnology is driven by two major developments. On the one hand, scientific progress allows for the development of completely new products, processes, and technologies for industrial application. On the other hand, further progress in the existing key technologies increasingly depends on the understanding and control of functional structures on the nanometer scale. Frequently, technological progress is hampered by a lack of understanding of structures on the nanoscale. It is the task of research to develop the respective know-how and to offer solutions for future technological problems and challenges. Nanotechnology is deemed a multi-disciplinary technology. For successful research and efficient implementation, very close cooperation of the various disciplines is required.

The Kompetenznetz "Funktionelle Nanostrukturen" (Competence Network on Functional Nanostructures) is a platform for target-oriented and multi-disciplinary research in the field of nanotechnology that comprises leading institutions in Baden-Württemberg. The Kompetenznetz is aimed at studying the fabrication, properties, and functioning of intelligent functional nanostructures and, thus, creating the prerequisites for future use and the systematic further development of existing applications.

The Kompetenznetz, the spokesmen of which are the Karlsruhe scientists Prof. Thomas Schimmel and Prof. Hilbert von Löhneysen, bundles the competencies in the field of functional nanostructures in the state of Baden-Württemberg. The research network makes use of existing synergies between the participating institutions. These are the universities of Karlsruhe, Constance, Stuttgart, and Ulm as well as the Forschungszentrum Karlsruhe and the Max Planck Institute of Solid-State Research in Stuttgart. Each of these partners has already been successful in establishing nanotechnology research. Concerning their focus of research, the partners complement each other in an ideal way.

Hence, the Kompetenznetz does not only contribute to the state-wide bundling of competencies in the field of functional nanostructures. It rather enhances the profiling of each of the six institutions in the field of nanotechnology.

The Kompetenznetz "Funktionelle Nanostrukturen" initiates and bundles multi-disciplinary cooperation of various nanotechnology research groups in

Baden-Württemberg, focusing on the fields of physics, chemistry, materials and engineering sciences, and biology. Competence in the field of functional nanostructures extends from chemical synthesis to physical experiments and measurement methods; from theoretical processes and simulation methods to application-oriented studies.

Activities of the Kompetenznetz "Funktionelle Nanostrukturen" concentrate on:

1. Cooperative, multi-disciplinary research projects relating to key issues of nanotechnology between leading institutions,
2. Support of scientific exchange between the research groups involved as well as specific promotion of young scientists in the field of nanotechnology,
3. Support of international cooperation.

At present, more than 200 scientists from 55 independent research groups are cooperating closely within this research network. Currently, twenty joint, multi-institutional, and interdisciplinary research projects are focusing on key issues of nanotechnology. These research projects are funded by the Landesstiftung Baden-Württemberg and the Ministry of Science, Research and the Arts, Baden-Württemberg) upon scientific evaluation of the Kompetenznetz and review of the individual projects by international reviewers. Up to five independent research groups, mostly from various research disciplines and from various locations and research institutions, are involved in each of these projects in order to reach a common research objective. Only by the cooperation of these different groups and institutions and by making use of their various competencies can the objectives defined be reached.

Current work focuses on the development of appropriate manufacturing techniques, the investigation of physical and chemical properties as well as on potential applications. In all projects, functional structures on the nanometer scale are in the center of interest, as their properties and interactions are decisive for a wide range of applications. Three major fields of applications of nanostructures can be distinguished. Accordingly, the activities of the Kompetenznetz "Funktionelle Nanostrukturen" are divided into three research areas:

- **A – Nanodevices**

It is focused on problems and applications in nanoelectronics, nanooptics, and nanomechanics

- **B – Functional Surfaces**

It is concentrated on nanostructured surfaces and interfaces, but also on nanostructures on surfaces

- **C – Nanoparticles and Nanomaterials**

It is focused on nanostructured materials and on the synthesis and properties of nanoparticles and clusters

These fields of research cover *three key areas for the technological applications* of functional nanostructures. Profound understanding of the properties and interactions of nanostructures in devices, on surfaces or in materials is needed for the further development of existing and the opening up of new applications. Examples range from nanoelectronics and nanooptics to medical engineering and sensor technology to the development of novel high-performance materials and layers. Various technologically relevant properties of materials, layers, and devices, e.g. electronic, optical, mechanical, tribological, adhesive or chemical properties, directly result from their structure on the nanometer scale.

The Kompetenznetz "Funktionelle Nanostrukturen" represents an interdisciplinary research endeavor, in which various disciplines from experiment to theory, from physics to chemistry, and from electrical engineering to materials sciences and life sciences cooperate very closely. The competencies and foci of the individual partner institutions complement each other in an ideal manner.

Th. Schimmel, H. v. Löhneysen, Ch. Obermair, and M. Barczewski

Nanotechnology is considered one of the key technologies of the 21st century. Increasingly small structures are gaining technological and economic importance. The scope of applications extends from car paints and catalysts to high-performance materials to medical applications to data stores and micro- and nanoelectronics, to mention but a few examples.

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The Landesstiftung Baden-Württemberg wishes to promote a lively and livable Baden-Württemberg. It paves the way for top research, a variety of education measures, and responsible contact with our fellow citizens.

The Landesstiftung is one of the large operative foundations in Germany. It is the only foundation that invests in the future of Baden-Württemberg and, hence, in the future of its citizens in an exclusive manner irrespective of affiliations to political parties.



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