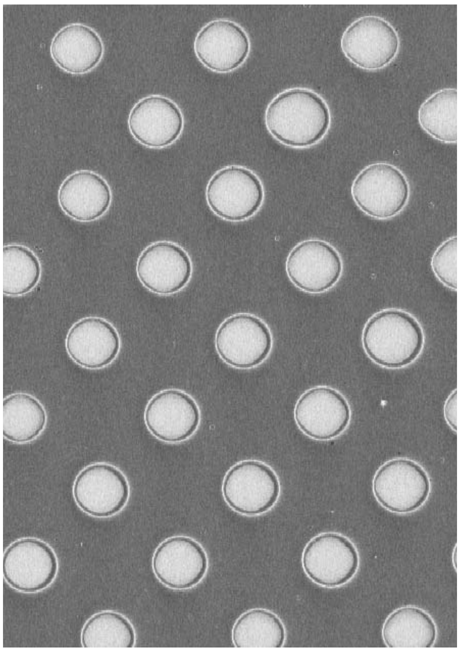
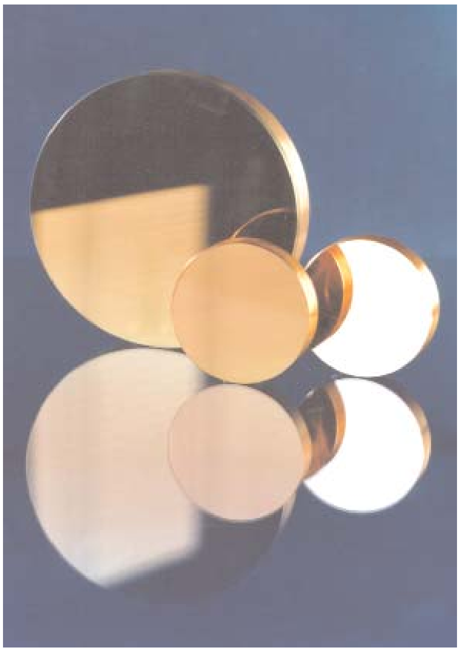
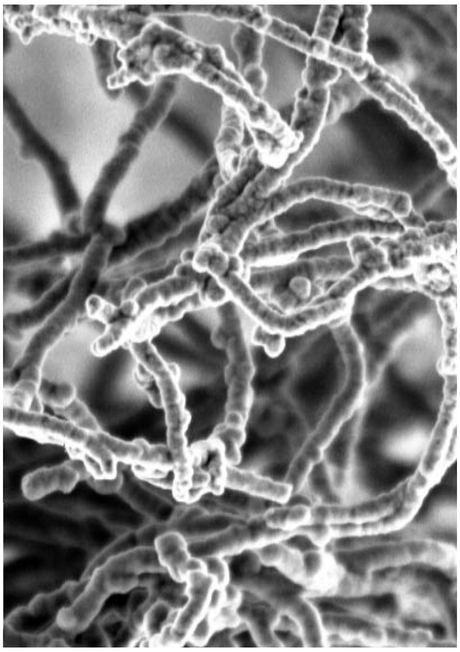






Nanotechnology Center of Competence “Ultrathin functional films”

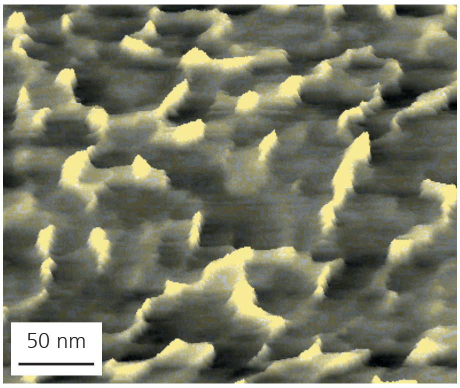
nanotechnology

CC "Ultrathin functional films”

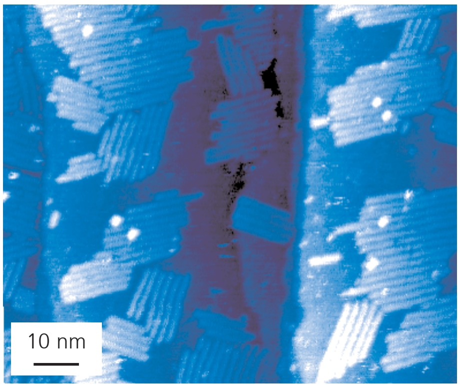
Objective of the center of competence

Nanotechnology belongs to one of the key technologies of the 21th century. Already today we have saleable products at hand such as hard disks and read heads for the data storage, which are coated with protective films only a few nanometers thin. Other products are for example scanning tunneling microscopes, which make the world of atoms and molecules visible or high precision x-ray optics. To these products belong ultrathin films for the microelectronic, prerequisite for a further increase of the integration density and the clock frequency, too.

Ultrathin films are a key element of nanotechnology. Their applications extend from the microelectronic and optic to medical science and sensor elements to wear protection layers. In order to consequently explore the industrial application possibilities 51 enterprises, 10 university institutes, 22 research establishments as well as 6 syndicates focused their know-how and jointed to a network, which is sponsored by the Federal Ministry for Education and Research as a center of competence for ultrathin films.



AFM picture of a surface of a titanium-platinum layer tempered at 700 °C
(source: Fraunhofer-Institut für Keramische Technologien und Sinterwerkstoffe Dresden)



STM picture of ultrathin paint layers on metals
(source: Technische Universität Dresden)

Tasks

The close cooperation and the coordination of all members involved within the center of competence secure an efficient use of available resources and enable quick solutions.
The following activities help us to achieve our objectives:

- organization of workshops and courses
- presentations on fairs and conferences
- coordination of research and development projects
- promotion of education and training
- support of potential entrepreneurs
- support of the standardization and the development of technological rules
- public relations

The agency of the center of competence will assist in putting various technical equipment and the know-how at the disposal of any interested customer. We offer the following services:

- consulting service
- feasibility studies
- reports
- realization of research and development activities
- process tests
- joint system development

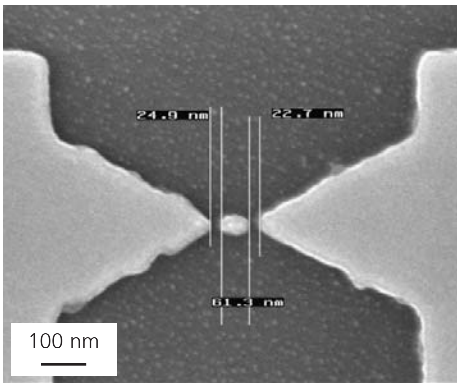
Research groups of the nanotechnology center of competence

Multi chamber ECR-RIE system with automatic sample transfer system for fluorine and chlorine processes
(source: Roth & Rau AG Wüstenbrand)

Research group 1: Advanced CMOS

The present CMOS technology masters structure sizes of 250 nm. For the semiconducting technology the road-map of the Semiconducting Industry Association SIA even prognoses a decrease of structure widths down to less than 100 nm within the next 10 years. These trends are accompanied by the requirements of increasingly higher clock frequencies and reliability. The solution to these complex problems requires innovative processes and material developments for active transistor regions and more and more also for the interconnection wiring systems. This is accompanied by the development of specific equipment for processing silicon wafers of increasing diameters.

Present wiring systems consist of contact materials ($TiSi_2$), barrier layers (TiN, TiW), interlevel dielectrics (SiO_2), via contacts (W-plugs) and interconnection wirings (Al alloys). Copper with its increased electro migration stability and its lower specific electric resistance is considered to be a new material to replace aluminum-based wirings. From copper an improved reliability and increased clock rates are expected. However, the introduction of copper as a new material requires a reproducible deposition and structuring technology at these small dimensions (aspect ratio > 3:1) and the introduction of barrier layers to block unwanted interactions (interdiffusion / reaction) with adjacent materials. The barrier layers may have only a negligible influence on the effective wiring resistance. This can only be realized by ultrathin (< 10 nm) barrier layers.



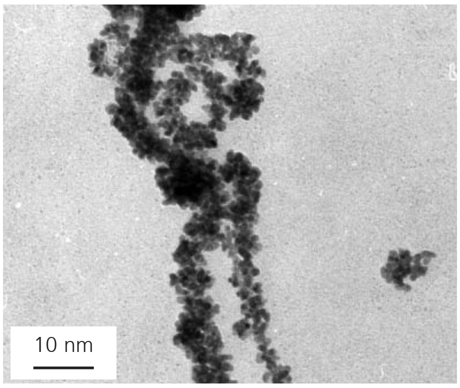
REM picture of a metal cluster between two contact tips
(source: Technische Universität Chemnitz)

Research group 2: New Devices

The progressing miniaturization of highly integrated circuits has increased the effort to complement and / or to replace gradually conventional CMOS technology in the near future by nanotechnologies and nanoelectronics. These technologies include among others, the magneto electronics and single electronics, including nanocluster memories and resonant tunneling devices.

Within the field of magneto electronics, semiconducting magnetic field sensors shall be replaced by the help of the giant magneto resistance (GMR) while CMOS memories should be substituted by nonvolatile magnetic memories (M-RAMs). For these devices it is necessary to deposit exactly a sequence of extremely thin layers of metals and insulators (single layer thickness app. 1 nm) and to precisely adjust the structure of the surface layers.

A new generation of devices is based on the effects of charge transfer of single or a few electrons in nanoscaled structures (single electronics). The main research effort lies on memory elements realized by charge transfer of single electrons between metallic clusters or on elements, which use the memory properties of semiconducting nanoclusters (nanocluster memory) in thin SiO_2 layers.



Metallization of DNA with palladium
(source: Technische Universität Dresden)

Research group 3: Biological Molecular Layers for Medicine and Engineering

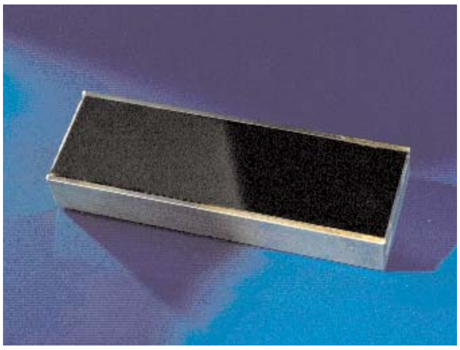
At present completely new perspectives can be seen for the interaction between the fields of molecular biology, medical basic research and pharmacology and the field of engineering disciplines and for the economic conversion of the results. Here the nanotechnology has to be taken into special consideration. Biological evolution has produced nanostructures with high complexity and functionality. The aim of this new interdisciplinary research is to open biological materials to technical application. New materials should be developed in the application fields of medicine (intra- and extra-corporal biomaterials) and engineering (nanotechnics, sensory, microelectronics and catalytics) based on the knowledge of the composition as well as the constitution, configuration and conformation of biomolecules and their connection to complex structures as well as the resulting functionality. In these fields the biological structures are components for the construction of composites with conventional materials, functional matrices for the synthesis or other e.g. inorganic nonmetallic phases (biomineralisation), templates for the deposition of metallic polymers and ceramic substances (nanostructured materials) as well as functional units for the development of microelements and reactors. The use of the nano biomolecular templates can be carried out only by creating ultrathin layers or cluster structures.
It is the objective of the center to investigate the range of 1 nm to about 100 nm by use of the bimolecular templates for layer- and cluster synthesis.

Consolidation of a damaged ceiling with nanoscaled SiO_2 at a manor's court near Riesa
(source: Feinchemie Sebnitz GmbH)

Research group 4: Nanometer scaled protective layers

Mechanical properties of thin films in the medium thickness range (10-100 nm) are widely used in industry, e.g.:
- as multilayers for wear protection-, oxidation- and shock-resistant tool coating
- as interlayers improving adhesion, sticking or wetting in plastics processing and compound materials technologies, in food technology and for architectural glass
- as gliding films under mixed friction and dry run conditions.

The members of the center have many years of experience in the development and application of such thin films. Based on the know-how for the medium nm-range, ultrathin films, i.e. of thickness below 10 nm, become more and more interesting with respect to industrial applications. This is due to the possibility of realizing novel mechanical or other properties in ultrathin films or systems.



Precision x-ray mirror for x-ray diffraction and microscopy, produced by the means of pulse laser deposition
(source: Fraunhofer-Institut für Werkstoff- und Strahltechnik Dresden)

Research group 5: Thin layers for Optics and Photonics

In modern optics and optoelectronics ultrathin films and layers with nano-structured components are very often of utmost interest. Especially for active optoelektronic devices the deposition and functionalization of ultrathin layers - partially with active single probe molecules - is subject of intensive research.

Semiconducting nanoclusters for silicon based light emission and organic LEDs are current examples based on the new light emitting materials. X-ray optical components, consisting of multi stacks of ultrathin layers with only little nanometer thickness, are presently applied as beam forming x-ray mirrors in the field of x-ray analytics and become more and more important. For the EUV lithography, which is considered to be the most promising future lithography process, the requirements to the x-ray optics are explicitly higher and demand a consequential further development of the coating processes and of the methods to produce ultra smooth substrates.

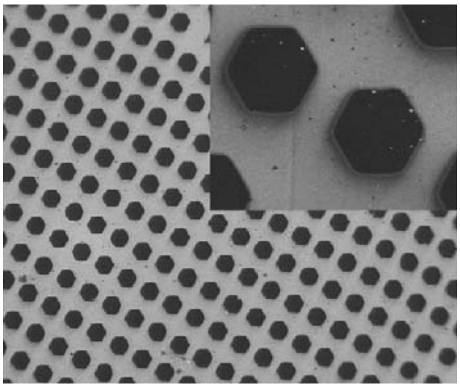
Lower thickness sensor with vakuum flange
(lower measuring range limit 30 ... 50 nm, depending on the material)
(source: amtec Analysenmeßtechnik GmbH Leipzig)

Research group 6: Nanoscaled sensors, actors and systems

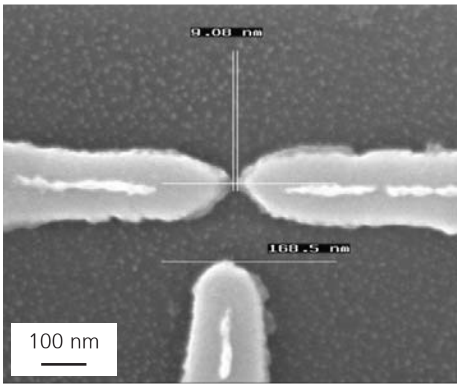
Microelectronical, microacoustical and microoptical systems are subject of current R&D as well as industrial production for a quick expanding market. Si-based circuits, surface acoustic wave (SAW) devices and micromechanical / microfluidical units serve as basic structures. Integration of the sensor and actor materials is realized by coating processes such as PVD, CVD, laser ablation and sol-gel techniques.
As an example SAW devices are mainly used in the field of telecommunication, where increasingly higher frequencies and shorter wavelength are used. Therefore a scaling down to the nanometer range of the transducer structures is necessary. Compact communication systems of the next generation will use frequencies from 10 to 15 GHz. This requires a lateral structure size from 50 to 100 nm and a layer thickness in the range from 10 to 30 nm.

High importance is given to the activation of surfaces in order to couple them with anorganic and organic functional elements. Examples here are the use of bacterial surface proteins for the production of sensors and the development of thin organic layers for biosensors and microreactors.

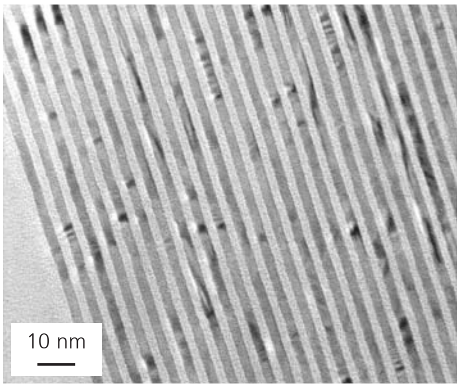
Structure and Organization



Ultrathin structured biopolymer films (35 nm), produced by surface polymerization (source: Institut für Polymerforschung Dresden)



Single electron transistor structure with contacts to test the electrical characteristics (source: Technische Universität Chemnitz)



TEM picture of a Ni/C multilayer (period thickness 4,6 nm) consisting of 50 periods with high regularity (source: Fraunhofer-Institut für Werkstoff- und Strahltechnik Dresden)

Structure

At this time 10 university institutes and 22 research establishments participate in the center of excellence. Furthermore 51 enterprises and 6 syndicates cooperate, within the center, including the semiconductor companies Infineon and AMD from Dresden.

The involved companies and institutes act juristically on their own authority. The single research groups are managed by spokesmen who organize the cooperation and coordination of the partners.

Nanotechnology Center of Competence
"Ultrathin functional films"
Office

c/o. Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS

Winterbergstr. 28
01277 Dresden
Germany

Fax	+49 (0) 351 2583 300
Internet	http://www.nanotechnology.de

Contact Partner:
Dr. Andreas Leson
Phone	+49 (0) 351 2583 317
E-mail	andreas.leson@iws.fraunhofer.de

Dr. Ralf Jäckel
Phone	+49 (0) 351 2583 444
E-mail	ralf.jaeckel@iws.fraunhofer.de

Organization

Outwardly the center of competence is represented by a counsel to which the following persons belong:

Prof. Dr. Thomas Geßner
Technical University of Chemnitz
Center for Microtechnologies

Dr. Andreas Leson
Fraunhofer Institute for Material and Beam Technology Dresden

Prof. Dr. Wolfgang Pompe
Technical University of Dresden
Institute for Material Science

Representatives of industry and banks consult the center of competence in order to organize precisely future R&D activities. The organizational realization of the planned activities is executed by the agency of the center at the Institute for Material and Beam Technology, which acts at the same time as contact point for internal and external inquiries.

Title pictures:

Left: Production of thin structured polymer films by surface controlled wetting (source: Institut für Polymerforschung Dresden)
Middle: Copper mirror for CO_2 laser coated with diamond-like carbon (source: Fraunhofer-Institut für Werkstoff- und Strahltechnik Dresden)
Right: Microtubuli - metallized with nickel (source: Technische Universität Dresden)