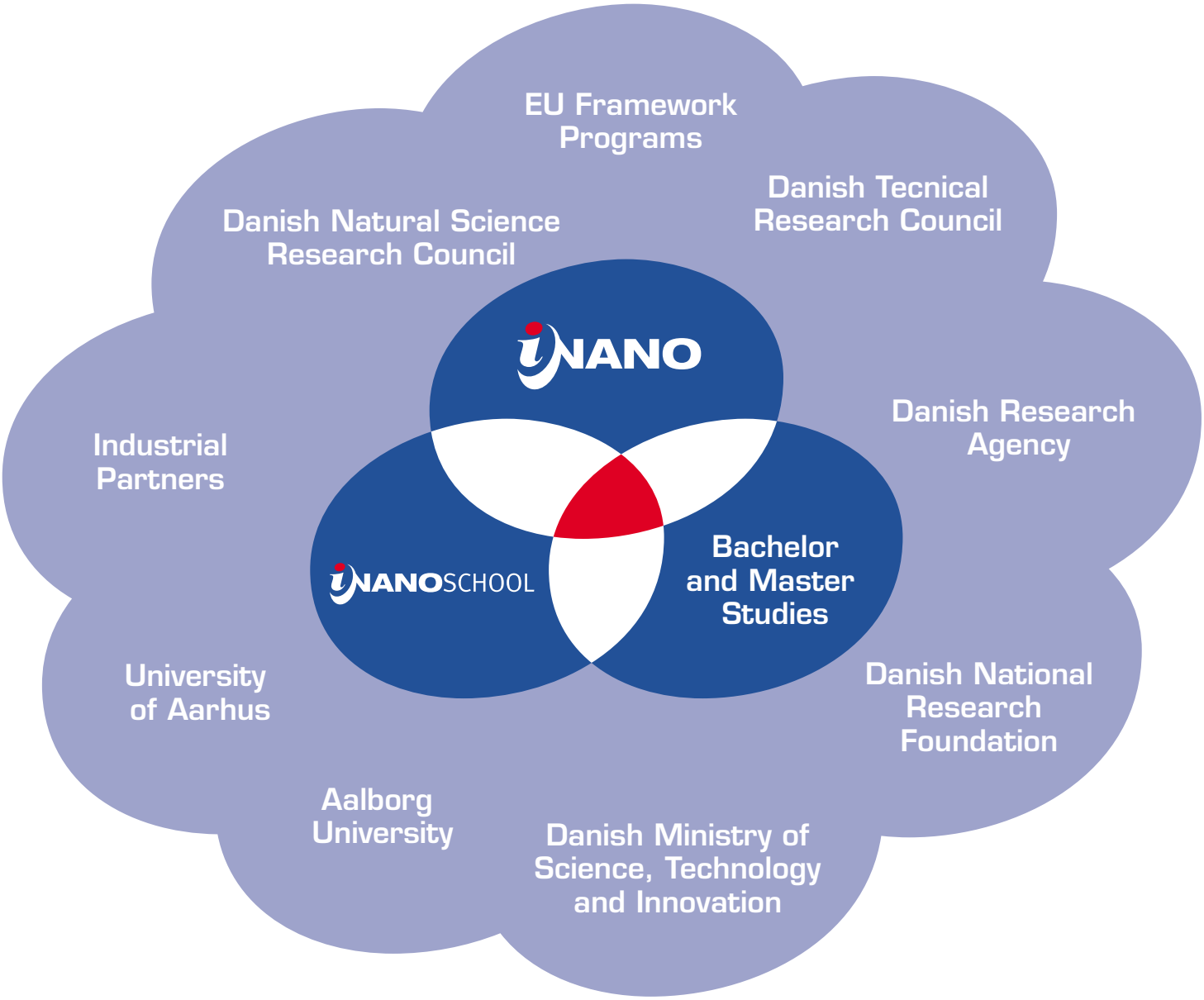
Funding structure of iNANO



The above figure shows the different funding sources supporting iNANO research and education. The first research grant was allocated in May 2003 from the Danish Research Agency under the programme Danish National Initiative in Nanotechnology and Nanoscience where iNANO received a grant to establish four initial targeted projects. Under the Danish Natural Science Research Council (SNF) and the Danish Technical Research Council (STVF), furthermore, iNANO is part of several instrument centres, such as the *Danish Biotechnological Instrument Center*. iNANO groups participate in a number of Centers of Excellence and Større Tværgående Forskergrupper ("Interdisciplinary Center of Excellence"). The Scanning Probe group within iNANO has been funded for 10 years by a grant from the Danish National Research Foundation through the Center of Excellence Center for Atomic-scale Materials Physics (CAMP). iNANO scientists participate in two Innovation consortia granted by the Danish Ministry of Science, Technology, and Innovation. iNANO participates in a number of EU Framework Programme 6 projects, e.g. in the prestigious Network of Excellence, Frontiers. iNANOschool, the graduate school associated with iNANO, is funded by a large grant from the Danish Research Training Council (FUR), which has been tripled by comparable contributions from i) the Faculties of Natural Science and Health Sciences at the University of Aarhus and the Faculty of Technical Science at Aalborg University, and ii) industrial partners.

Organization

The broad guidelines for iNANO's efforts are decided upon in the iNANO board, which consists of representatives from industry and the two universities:

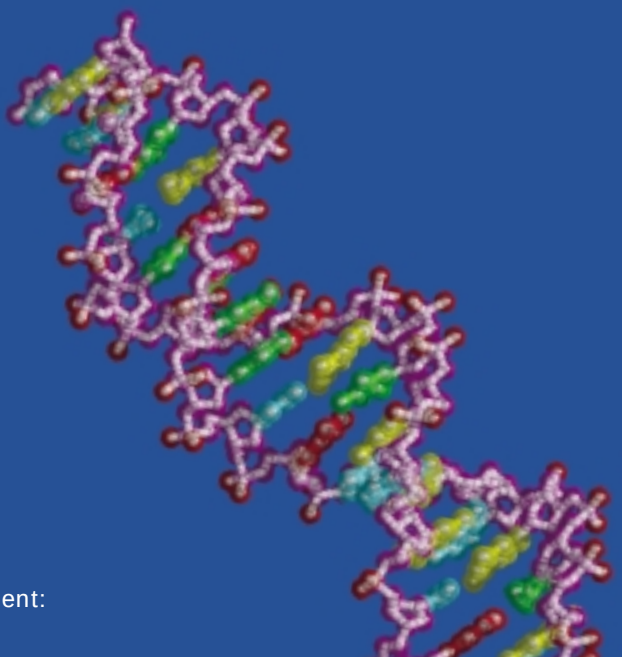
- Research Director Ove Poulsen, NKT Research A/S (chairman)
- Research Director Hans Jørgen Pedersen, Danfoss A/S
- Research Director Bjerne Clausen, Haldor Topsøe A/S
- Research Director Klaus Bock, Carlsberglaboratoriet
- Director Ole Jensen, NanoNord A/S
- Dean Erik Meineche Schmidt, Faculty of Science, University of Aarhus
- Dean Søren Mogensen, Faculty of Health Sciences, University of Aarhus
- Dean Finn Kjærsdam, Faculty of Science, Aalborg University

The center is directed by Prof., DrSc Flemming Besenbacher (Aarhus). Prof. Niels Chr. Nielsen (Molecular Biology, Aarhus) and Associate Prof. Kjeld Pedersen (Physics, Aalborg) act as Deputy Directors. All were appointed by the board.

Industrial partners

Several national and international companies have entered into a formalized collaboration with iNANO through their support of research and/or educational activities:

• NKT Research A/S	www.nkt.dk
• Danfoss A/S	www.danfoss.dk
• Haldor Topsøe A/S	www.topsoe.dk
• Carlsberglaboratoriet	www.crc.dk
• NanoNord A/S	www.nanonord.dk
• H. Lundbeck A/S	www.lundbeck.com
• Grundfos A/S	www.grundfos.com
• Exiqon A/S	www.exiqon.dk
• Novozymes A/S	www.novozymes.com
• Sagres Discovery (USA)	www.sagresdiscovery.com



Further information

Detailed information on iNANO can be found on www.inano.dk or by contacting the center management:

Prof., DrSc Flemming Besenbacher
Interdisciplinary Nanoscience Center, iNANO

University of Aarhus
Ny Munkegade
DK-8000 Aarhus C
Denmark

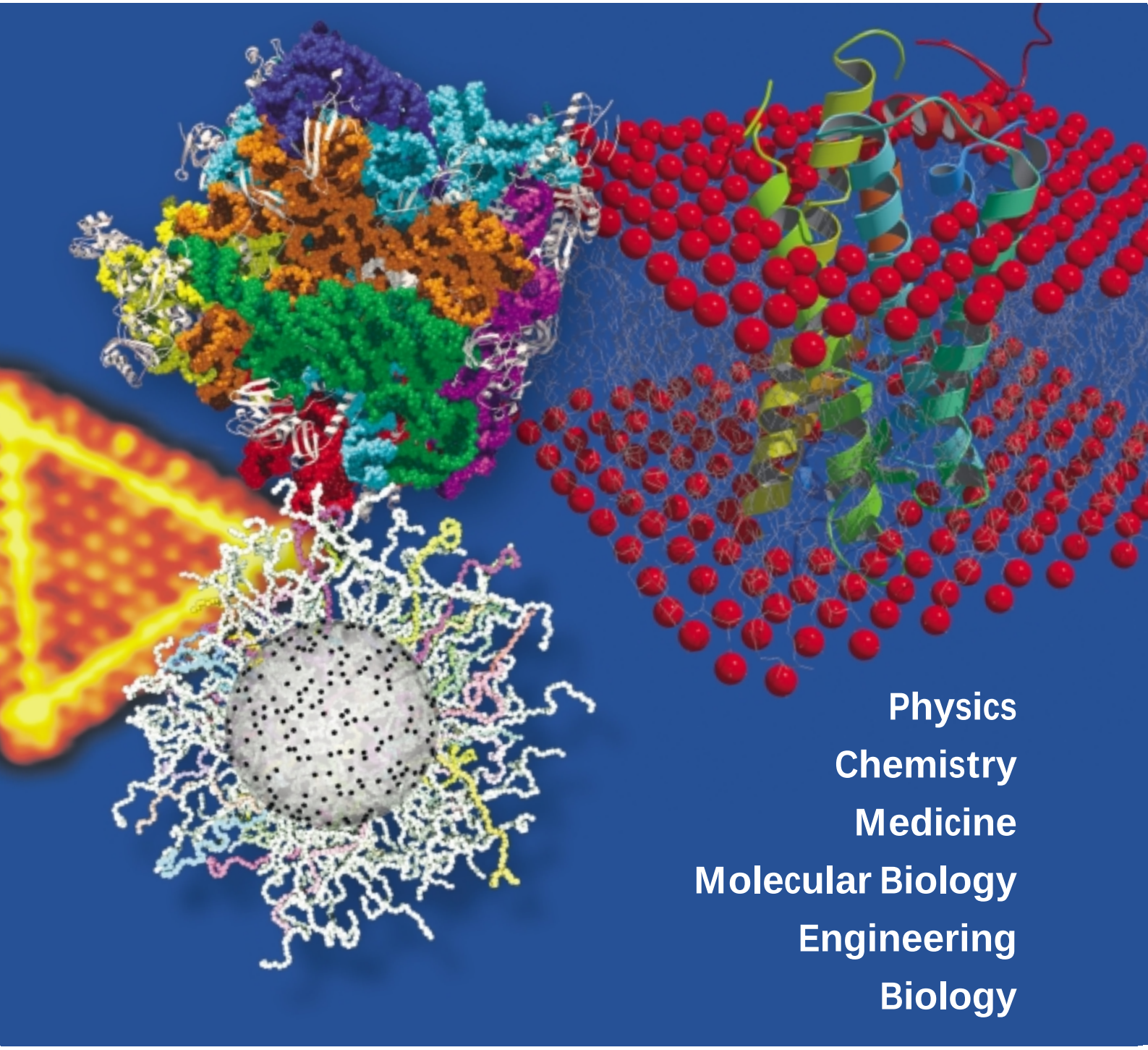
Email: fbe@inano.au.dk
Phone +45 8942 3604

Coordinator Peter Thostrup, PhD
Interdisciplinary Nanoscience Center, iNANO

University of Aarhus
Ny Munkegade bldg. 520
DK-8000 Aarhus C
Denmark

Email: thostrup@inano.au.dk
Phone +45 8942 3710

INTERDISCIPLINARY NANOSCIENCE CENTER

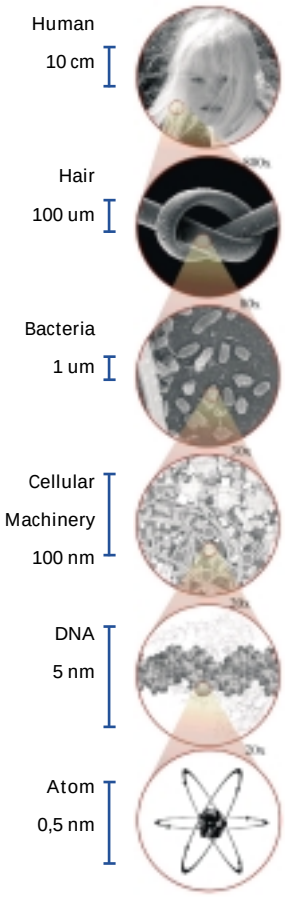


Physics
Chemistry
Medicine
Molecular Biology
Engineering
Biology

iNANO

What is nanoscience? What is nanotechnology?

The prefix "nano" originates from the Greek word for dwarf and thus refers to something small. As a prefix for a unit of time or length, it means one billionth of that unit. A nanometer (nm) is thus 0.000'000'001 meter. The dot over the letter "i" is approximately one million nanometers in diameter. The fundamental building blocks of nature - atoms and molecules - have dimensions in the nanometer range (i.e., the nanoscale). Many water molecules easily occupy a sphere of 1 nm in diameter. The DNA double helix is approximately 2 nm wide.



The way molecules assemble into larger, supramolecular entities on the nanoscale determines important material properties (e.g., electrical, optical, and mechanical properties). Of course, it has long been recognized that nature performs this assembly very well in the creation of the sophisticated molecular machinery that supports life. In short, by controlling structures on the scale of ~1 – 100 nm, one can, in principle, ultimately design new materials with specific properties.

Scientists have long imagined the possibility of manipulating individual atoms and molecules. Over the past 20 years a variety of tools have been developed, the so-called scanning probe microscopes, that indeed make it possible not just to "see" individual atoms and molecules on the surface of materials (i.e., create images), but to move atoms and molecules on the nanoscale as well. We are now in a situation where we can design new materials with new properties atom by atom.

Nanotechnology is the ability to operate at the atomic, molecular and supramolecular levels, on a scale from 0.1 – 500 nanometers, with the goal to design, create, manipulate, and apply materials, devices, and systems with novel physical, chemical and biological properties and functions caused by the small scale of their structure. Although most nanotechnological efforts are still exploratory, the lure of potential revolutionary applications has motivated huge investments in nanoscience, which addresses the fundamental phenomena occurring on the nanoscale and thus forms the knowledge base for nanotechnology.

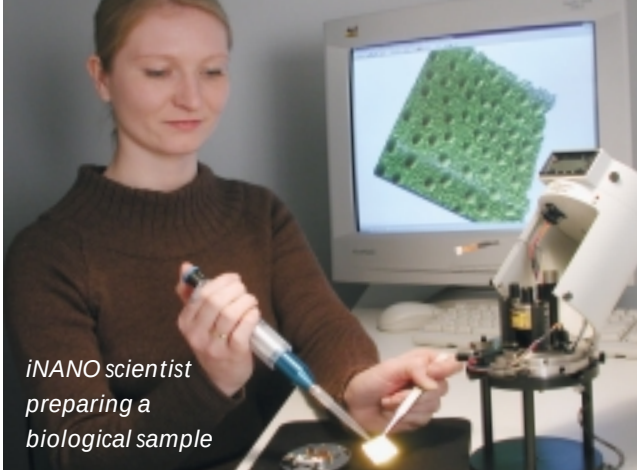
By itself, research on the nanoscale is not novel; scientists have studied atoms and molecules for more than a century. The novelty of nanoscience rather lies in the ability of researchers to characterize and synthesize well-defined nanostructures with unique properties. To fully capitalize on nanoscience and nanotechnology, it is clearly advantageous to work with teams that bring together interdisciplinary scientific expertise. Nature itself is indeed the most consummate nanoscientist. For instance, lessons learned from biology in relation to molecular self-assembly may significantly influence the design of tomorrow's nanoelectronics. The scientific width of iNANO is perhaps the center's most pronounced asset and ensures a favourable position in making competitive contributions to the field. The interdisciplinary environment of iNANO is anticipated to provide an excellent and fertile ground for future and, as yet undefined, ground-breaking discoveries with interesting perspectives for Danish and international industry.

The mission of iNANO

The Interdisciplinary Nanoscience Center (iNANO) fosters a comprehensive research, education, and development programme in the area of nanoscience and nanotechnology. Inaugurated in January 2002, iNANO is nucleated around the internationally recognized Scanning Probe Microscopy group "Center for Atomic-scale Materials Physics" (www.phys.au.dk/CAMP), headed by Prof. Flemming Besenbacher, who is now also Director of iNANO. The iNANO center provides a framework in which leading-edge expertise in physics, chemistry, molecular biology, biology, engineering and medicine are combined to create an interdisciplinary environment of international stature. The center is situated at the University of Aarhus, but recently a collaboration with Aalborg University was established within the areas of nanoscience and nanotechnology. Furthermore, present iNANO activities include participants from major industries throughout Denmark. Collaborations with international research groups and nanoscience centers provide the balance required for a scientific and educational endeavour on this scale.

The mission of iNANO is to strengthen the interdisciplinary research within nanoscience and nanotechnology, to catalyze collaborations with other international nanoscience research groups, and to play a key role in the education of the next generation of scientists within nanotechnology at the Bachelor, Master, PhD, and postdoctoral level. Furthermore, iNANO is committed to provide an innovative interface for transfer and transformation of basic nanoscience knowledge to nanotechnology in Danish industry.

iNANO scientist assembling a Scanning Tunneling Microscope



iNANO scientist preparing a biological sample

Comprehensive educational program

Because nanoscience and nanotechnology transcend traditional boundaries between scientific disciplines, the curriculum traditionally offered to students was altered. iNANO has established a new educational program that incorporates a broad spectrum of introductory, advanced, and specialized courses to give students a sufficiently broad basis to conduct interdisciplinary research and at the same time achieve disciplinary depth and specialized skills in selected areas.

Bachelor and Master Studies

In January 2002, the Danish Ministry of Science, Technology and Innovation approved the new nanoscience education at the University of Aarhus (www.iNANO.dk/master) in which 37 first-year students enrolled in the Autumn of 2002 and 45 in 2003. The bachelor programme covers basic disciplines of physics, chemistry, biology, and mathematics, and incorporates individual and group projects into the curriculum to a wider extent than do conventional science educations. Master students engage in more specialized courses and projects relevant to their subsequent thesis work. To further expand the curriculum, "Center for Applied Sciences" at the Faculty of Science, University of Aarhus has in collaboration with the Engineering College of Aarhus and iNANO established a new education programme for nano-engineers starting in the Autumn of 2003. Furthermore, a Bachelor/Master programme in nanotechnology and engineering has been initiated from September 2003 at Aalborg University, coordinated with the educational activities in Aarhus.

The iNANOschool

In December 2002, iNANO received a large grant from the Danish Research Training Council (FUR) to initiate the PhD graduate school "iNANOschool" (www.iNANOschool.dk), with a volume of approximately 50 PhD students. This grant released further funds from the Faculties of Science and Health Sciences, the County of Aarhus, and seven national and international companies. The result of the latter funds was a trebling of the original FUR grants which in turn makes it possible for us to award further PhD stipends. The first international call for applications to the iNANOschool was published in February 2003 and 15 new students were enrolled.

Industrial Contacts, Knowledge Transfer, and International Relations

An important element of iNANO is the interaction with national and international companies, see backside for a list of collaborators. The iNANO board includes representatives from some of the companies with interest and expertise in nanotechnology. Through a collaboration with NanoNord (www.nanonord.dk), clean room facilities will be established at the University of Aarhus to provide the necessary environment for collaborative projects with industry and to strengthen research and educational activities. Furthermore, microelectronics production facilities are being established at NanoNord close to Aalborg Universitv

Biocompatible hip implant

In addition to an extensive network of international collaborators in specific research areas, iNANO has close contacts and relations to leading nanoscience centers throughout Europe, USA and Japan. A key asset of this association is the education of students through exchange programs. The extensive interaction with European countries forms the background for the participation of iNANO in a large number of applications for EU Framework Programme 6 (FP6) projects.

Photonic cystal fiber developed by NKT

Research themes

The iNANO research center constitutes a large conglomerate and currently consists of more than 110 scientists from different fields coordinated by a robust organisation. Current research within the iNANO framework falls within six target areas:

Bio-nanotechnology

Nature itself is a rich source of nanoprocesses and advanced nanomachinery. The understanding of structure-function relationships for biological macromolecules, and the ability to perform appropriate manipulations form the basis of bio-nanotechnology. Within this area, iNANO performs research on topics such as:

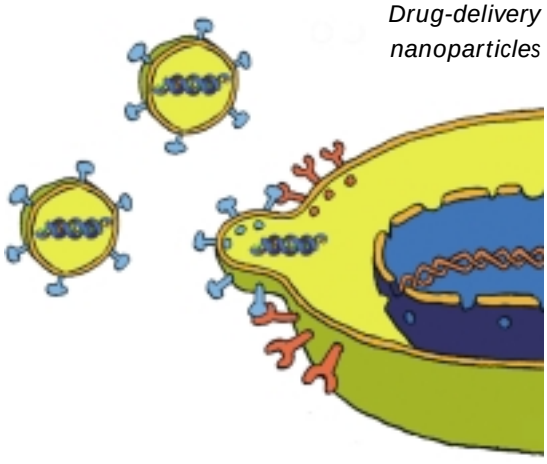
- Biosensors based on conformational changes in biomolecules
- Structure and function of biological macromolecules
- Nanomotors

Nanomedicine

Knowledge about cell communication can facilitate the creation of nanodevices able to travel through the human circulatory system, tracking down diseased cells and either repairing the abnormality by intracellular "surgery" or destroying the cells. iNANO research topics cover:

- Drug-delivery nanoparticles
- Membrane proteins as therapeutic targets
- Biocompatibility
- Nanostructures in ophthalmology

Drug-delivery nanoparticles



Molecular Nanostructures

Molecular nano-architectures designed to have specific functions are a key element in nanotechnological fields such as molecular electronics, surface functionalisation or biochemical nanosensors. Such investigations include:

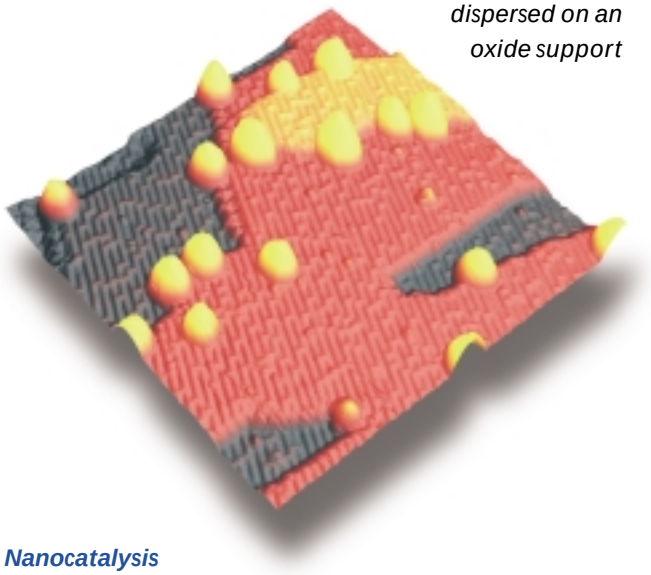
- Molecular self-assembly and surface functionalisation
- Molecular electronics

Functional Nanomaterials

Materials composed of nano-size structures may possess novel physical, chemical or biological properties that can be utilized to perform specific functions unattainable with conventional materials. The availability of such functional nanomaterials is likely to revolutionize industrial manufacturing capabilities and capacities to an extent we can hardly envision. iNANO research focuses on:

- Nanocrystals in silicon-based semiconductors
- Nanocrystalline materials
- Thermoelectric materials
- Nanomagnets
- Nano-photonics

Gold nanoclusters dispersed on an oxide support



Nanocatalysis

Understanding the chemical reactivity of nanometer-sized particles and/or clusters is crucial for developing new energy-efficient processes for the chemical industry. The chemistry of such nanoparticles used in heterogeneous catalysts is widely different from their macroscopic counterparts. So far a general description of nanoparticle reactivity is lacking but the work within iNANO on nanocatalysis using Scanning Tunneling Microscopy has led to unprecedented progress in the understanding of catalyst reactivity.

Long-term Generic Nanoscience

The explosion of nanoscience as a viable domain of research derives to a large extent from the development of tools that allow us to investigate phenomena that occur on the nanoscale. In the same spirit, we believe that the development of new tools that complement and extend the methods currently available will influence the future of nanoscience significantly. To this end, we are exploring novel experimental and theoretical techniques that will expand the existing repertoire within iNANO.