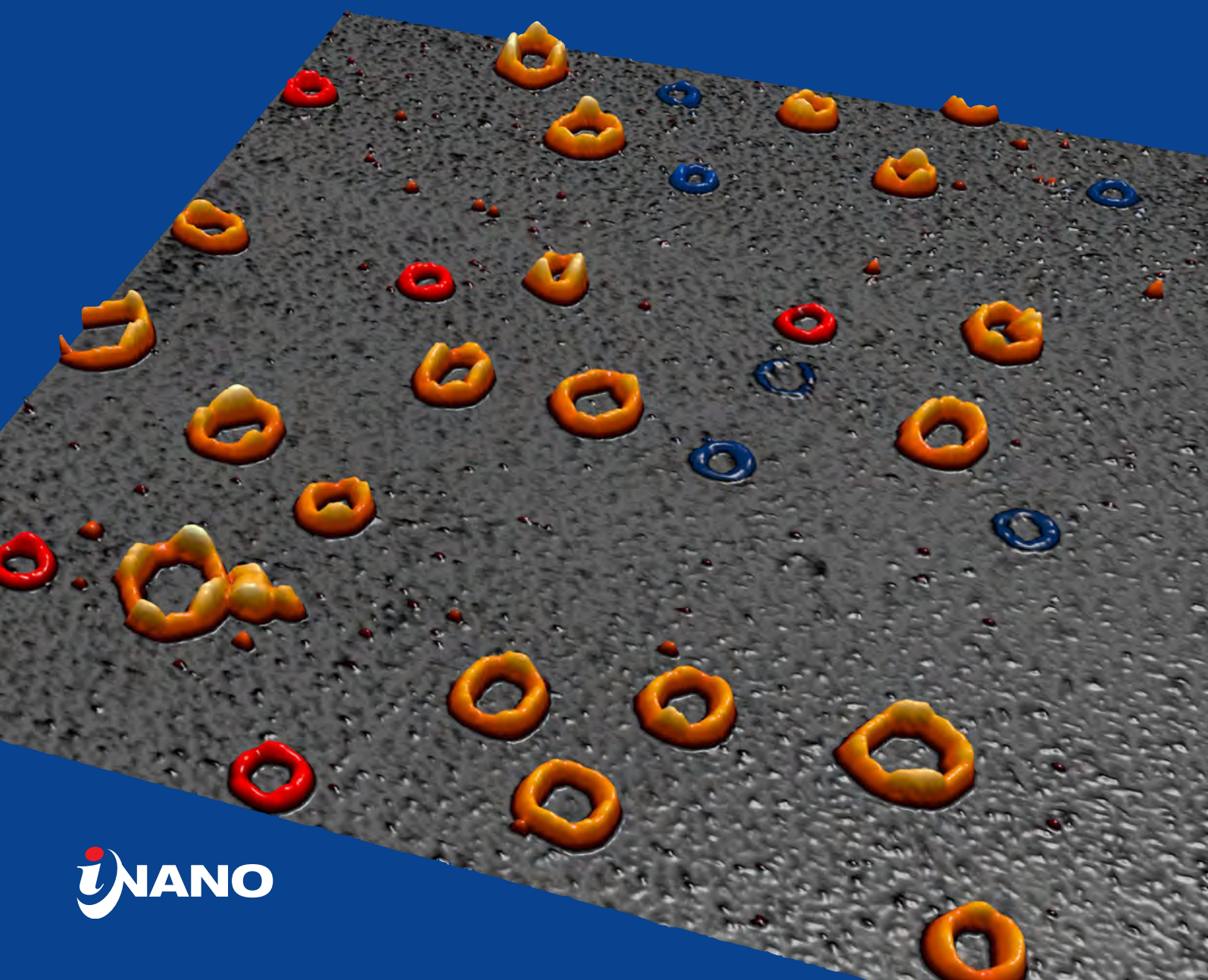
AARHUS
UNIVERSITY

iNANO ANNUAL REPORT 2011

EDUCATION · SCIENCE · iNANO & INDUSTRY · COMMUNICATION & AWARDS · STAFF



iNANO

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Annual report 2011, published May 2012
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Editors: Kaj Jensen, Annette Wandahl and Flemming Besenbacher, iNANO and Rolf Haugaard Nielsen
Design: Britta Munter / AU Communication, Aarhus University
Printed in Denmark by Form og Farve

Photographers: AU Communication, page 7 (small), 19, 27. ATV / Tom Jersø, page 37 second column, Euspen, page 15 (right). Jens Larsen, page 20. Jesper Rais / AU Communication, page 7 (large), 23. Lars Kruse / AU Communication, page 5 (bottom), 8, 14, 38, 39. Roar Lava Paaske / AU Communication, page 5 (top), 18, 21, 24. Other photos, iNANO.

Cover photo
Atomic Force Microscopy image of insulin deposited on a surface. By tuning the ratio of two co-secreted human proteins, the nano-structure morphology changes from fibrils to oligomers to annular. Read more about this study on pages 32-33.

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MESSAGE FROM THE DIRECTOR

It is with great pleasure that I present the annual report for the Interdisciplinary Nanoscience Center, iNANO, for its tenth anniversary year.

As of 1 January 2012 I took up the position as Chairman of the Carlsberg Foundation and as of 22 March 2012 I was elected Chairman of the Board of Trustees of the Carlsberg Brewery, for which reasons I decided to step down as the center director of iNANO as of 1 February 2012. After leading iNANO for 10 successful years, I passed on the torch to Professor Niels Christian Nielsen. I am completely confident that Professor Niels Christian Nielsen will be able to further strengthen iNANO's current standing as one of the world's leading international nanoscience centers. At the same time, Professor Jørgen Kjems will take over the leadership of the graduate PhD school, iNANOschool, from me.

iNANO was inaugurated on 28 January 2002, in the presence of the former Minister of Science Helge Sander while Nobel Laureate Heinrich Rohrer and Professor Andreas Engel presented two scientific lectures. Already from that day I personally had great visions and expectations on behalf of iNANO with its continuing mission resting on three columns: Education, research and technology transfer to society. However, few might then have predicted that iNANO would grow to its current stature with 35 research groups, 60 postdocs, and 150 PhD students. In 2002 the catalyst for the establishment of the iNANO Center was actually the truly unique new nanoscience study line, which started in 2002, after approval by the Danish Ministry for Education. Today we have an annual uptake of approximately 40 Bachelor's degree students at the nanoscience study line. iNANO has created numerous links to industry, filed several patents, catalysed several smaller spin out companies and has been able to attract more than DKK 700 million in external funding from research councils and foundations since 2002.

Again in 2011 we witnessed exciting research being performed by the iNANO scientists. What I find especially pleasing is the high number of talented young people who were recognized for their outstanding achievements, exemplified by the many awards and high number of grants which they won in tough national and international competitions. In January 2011, Professor Bo Brummerstedt Iversen (iNANO and Dept. of Chemistry) was awarded the prestigious Eliteforsk (elite researcher) award for his outstanding research in nanoscience and materials chemistry. Doctors Ebbe Sloth Andersen and Rikke Meyer were awarded the prestigious Sapere Aude grant from the Danish National Research Council, which is given to young, outstanding scientists (see elsewhere in the annual report). These two bright, young scientists are examples of the strengthened focus on talent development at Aarhus University. 2011 was also the year where the first European Young Researcher Award was granted. The committee unanimously decided to give the award to Dorthe B. Ravnsbæk from iNANO for her "exceptional scientific quality and European dimension of the research performed". Again, congratulations to Dorthe.

Dr. Brigitte Städler was awarded the L'Oreal-Unesco fellowship "for women in science", providing visibility and encouragement for the exceptional quality of the recipients' work. For the second year in a row Dr. Brigitte Städler received a big award, which is a great acknowledgement of her work, and an indication of iNANO's capability to attract some of the most talented, foreign, young scientists in the world. A truly wonderful example of brain gain.

Finally I would like to mention the Bachelor's students participating in and winning the BIOMOD competition at Harvard University. I am truly impressed by our young Bachelor's students, who showed a lot of creativity, hard work and great presentation skills, and were able to win this though international competition. The future of iNANO looks promising with this next generation of students produced by our own study line.

Besides the outstanding research, education and impressive achievements mentioned before, 2011 was an exciting year at Aarhus University. The University underwent a major reorganization process, which meant that the transition to the new iNANO leadership took place at an even more exciting time. This all-encompassing reorganization of Aarhus University has as an underlying impetus the promotion of "interdisciplinarity", a concept that has already shown its worth at iNANO in abundance. This fortunate development positions iNANO even stronger in the new organization and ensures goodwill at all levels. I am proud that iNANO is often referred to as a role model for new interdisciplinary centres at the newly restructured Aarhus University.

Even more exciting events are to come as the iNANO building is set to open in the fall of 2012. Being in the same building will ensure closer formal and informal interaction between the different interdisciplinary research groups from physics, chemistry, biology and molecular biology while working together on joint projects. The iNANO building will have an impressive suite of state-of-the-art nanosynthesis and nanoanalysis instrumentation, the likes of which cannot be found anywhere in Northern Europe. I am very much looking forward to seeing the new 10,000 m^2 building buzzing with life and ideas.

Personally, I shall retain my professorship at a 50% level at iNANO and split my time between my new obligations at the Carlsberg Foundation, the Carlsberg Group, and iNANO. I shall do my very best to ease the transition to the new iNANO leadership, letting it run its own agenda without interference, but I will of course always be available when called upon for strategic discussions. I shall also continue to activate my personal international network when asked.

I would like to take this opportunity to THANK former and current iNANO staff members, post docs, PhD students, and Master's and Bachelor's students without whose dedication and skills we would never have come this far. I will also like to express my sincere thanks to the previous and current Deans, Karl Pedersen, Erik Meineche Schmidt, Brian Bech Nielsen, and our Rector Lauritz B. Holm-Nielsen and the Board of Aarhus University for their support to the new iNANO building. Without their continuing strong support during the last 10 years it would not have been possible to manage and constantly expand iNANO within a challenging matrix management structure interfaced to several different departments and Faculties. Last, but not least, BIG thanks go to the iNANO administration and the scientific coordinators. You are "probably" the most competent, professional and LEAN centre administration at AU.

I have had 10 fantastic years as the director of iNANO, and I would like to express my sincere wishes for the future success of iNANO.

Professor Niels Chr. Nielsen was appointed Professor at the Department of Molecular and Structural Biology, University of Aarhus, in 1999. He established as part of the Danish Biotechnological Instrument Centre (DABIC) the Laboratory for Biomolecular NMR at Aarhus University aimed at developing and applying advanced solid- and liquid-state NMR methods in structural biology. In 2004 he was appointed Professor in Chemistry. Funded by the Danish National Research Foundation he established the Center for Insoluble Protein Structures (inSPIN) in 2005. He has currently published 200 peer-reviewed articles. Niels Chr. Nielsen has also been involved in science politics as member of, e.g., the Natural Science Research Council and "Danmarks Forskningspolitiske Råd" in addition to being Fellow of the Danish Royal Academy of Sciences and Letters and the Danish Academy of Technical Sciences (ATV). He received the Direktør Ib Henriksen's Research Award in 2006 and the Danisco Award in 2007. Prior to his appointment to director of iNANO, he acted from the start of iNANO in 2002 as vice-director as well as vice-leader of iNANOschool.

iNANO IN **NUMBERS**

Since its inauguration in January 2002, iNANO has matured to one of the internationally leading nanoscience centers with strong track records within education (BSc, MSc, and PhD levels), research, technology transfer, industrial collaboration, and innovation in the form of spin-out companies.

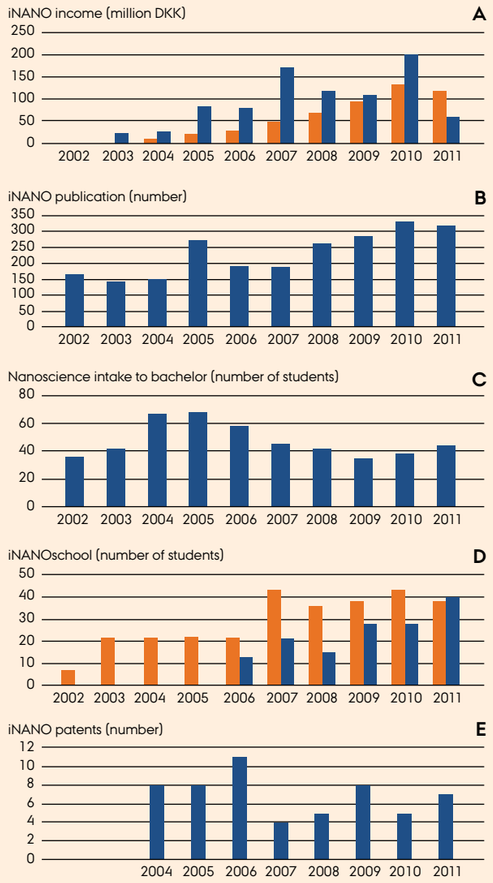
Today, ten years after its inauguration, iNANO has successfully been established as a collaborative interdisciplinary research center at Aarhus University, allowing for successful completion of research which would not be possible without different fields of expertise joining forces and strong support from the Faculty and the University. iNANO has attracted more than MDKK 700 in external funding (Fig. A) and publishes more than 300 papers per year (Fig. B), close to 10% of all publications from Aarhus University. iNANO has fuelled many industrial research collaborations, and importantly iNANO carries two well-run and highly recognised educational schools, including undergraduate studies on the BSc (Fig. C) and MSc levels and PhD education with currently around 150 PhD students (Fig. D) enrolled in the iNANOschool graduate program.

iNANO today has a core of 35 independent research groups, 11 satellite groups, and 14 collaborating medical groups involved in nanoscience research projects. The high international level of the research activities is demonstrated by the fact that iNANO currently houses three Centers of Excellence sponsored by the Danish National Research Foundation (in addition to being involved in four other such centers), one advanced ERC grant, five projects sponsored by the Danish National Advanced Technology Foundation, one center sponsored by the Lundbeck Foundation, and numerous projects sponsored by the Danish Councils for Independent and Strategic Research as well as several EU projects.

Since 2002 iNANO has enrolled 40-60 bachelor students yearly (Fig. C). A large fraction of the iNANO MSc students continue as PhD students, internationally or in the iNANO PhD programme, iNANOschool. In 2010, iNANOschool had around 150 PhD students enrolled (Fig. D). Approximately 40% of these have been recruited from abroad. iNANOschool has 19 Honours (3+5 yrs.) PhD students enrolled. 35% of the PhD projects have industry involvement, and 10% of the stipends are co-financed by industrial partners.

The total number of iNANO patents has now reached 56 (see Fig. E), and five small companies have been spun out, of which three with early investor capital.

A. iNANO Gross external funding totalling > DKK 700 million (orange) and turnover/year for iNANO's budget code (orange) 2002-2011.
B. iNANO peer-reviewed publications 2002-2011 as registered in PURE.
C. iNANO BSc student intake
D. iNANO PhD student intake (orange) and graduated (blue) at iNANOschool 2002-2011.
E. Total number of iNANO patents.



LABORATORY BUILDING COMPLEX FOR INTERDISCIPLINARY **NANOSCIENCE RESEARCH**

Since iNANO was inaugurated in 2002, the center has been faced with logistic challenges, as our associated researchers and their research groups are located at the various departments all over campus. In order to truly benefit from the interdisciplinary collaboration it was decided to build a new laboratory complex in which truly interdisciplinary science would be made possible.

2011 saw a lot of progress on the construction site, and two milestones, the placement of the foundation stone and the topping out ceremony, were celebrated this year.

The foundation stone was laid by City Councillor Jacob Bundsgaard Johansen, Rector Lauritz B. Holm-Nielsen, Dean Erik Meineche Schmidt and Center Director Flemming Besenbacher (iNANO) and contained, to mention a few things, the foundation stone document, the current days newspaper and the most recent iNANO annual report.

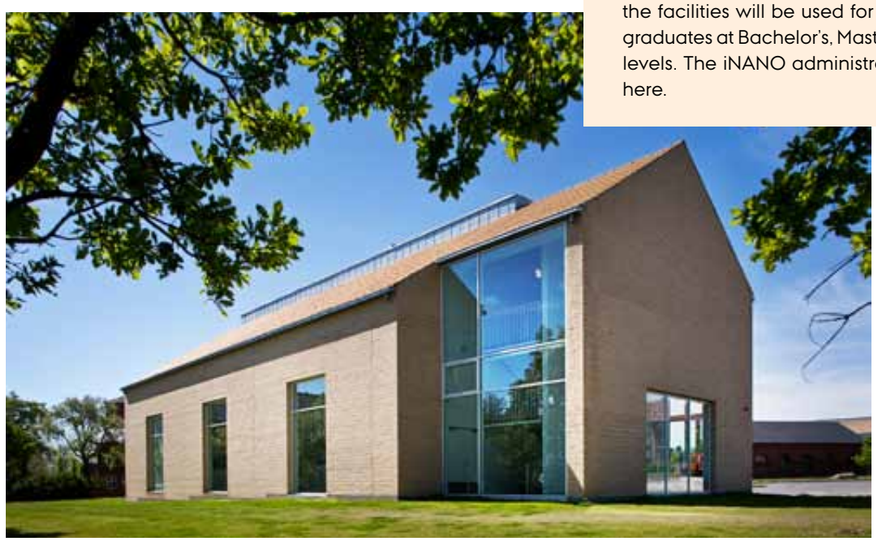
During the summer the topping-out ceremony took place. The new Dean of Science and Technology, Brian Bech Nielsen, the Director of iNANO, Flemming Besembacher, representatives from the property agency and the construction workers were among the guests, celebrating that the last beam had been placed on top of the building.

The building is expected to be completed by August 2012, and a large part of the iNANO researchers will then move into their new, state-of-the-art laboratories and teaching facilities.

Facts
The laboratory complex consists of three buildings divided into three floors, and the buildings will support a number of functions. A classroom section is to be set up, as well as several research sections with laboratories and offices for the different groups working there, and a section with competence laboratories providing special equipment and room for many internal and external users.

The laboratory complex will consist of the following

- A cleanroom, class 100: The components handled here are so small and sensitive that one single particle of dust can ruin the operation. High-efficiency filters and ducted air flow make sure that dust is kept out.
- Laboratories: There will be room at the basement level for a number of competence laboratories with some of the finest equipment in the world, including a 950 Mhz NMR and several Scanning Tunnelling Microscopes. These laboratories will provide scientists with the framework for performing research of a high international standard well into the future.
- Classrooms and administration offices: A large part of the facilities will be used for the education of science graduates at Bachelor's, Master's, PhD and postdoctoral levels. The iNANO administration will also be located here.



AN INTERDISCIPLINARY **CURRICULUM** FOR **NANOSCIENCE**

Interdisciplinarity lies at the core of nanoscience and nanotechnology. Many of the most groundbreaking current developments take place at the boundaries between the traditional disciplines of physics, chemistry, molecular biology and biology. This observation, along with the fact that the years of undergraduate education define our mental framework and approach to science to a large extent, calls for an early introduction to all the core disciplines of nanoscience. At iNANO we offer dedicated Bachelor's and Master's programmes in Nanoscience where the goal of disciplinary breadth has been realized without sacrificing scientific depth. This has been accomplished by developing a fixed course programme involving carefully selected elements from the core disciplines in combination with dedicated nanoscience courses and elective specialisation modules during the last years of study. Since its introduction in 2002 the annual uptake on this new study programme counts 40-60 highly motivated and dedicated young students.

Bachelor's programme

During the first three years, students receive basic interdisciplinary training in physics, chemistry, biology, molecular biology, mathematics and computer science. Many courses are followed along with students from these core disciplines. In addition, a number of courses address issues specific to the nano-area. In the course "Introduction to Nanotechnology" the first year students are introduced to key nano-concepts such as scanning probe techniques and bottom-up/top-down synthesis of nanostructures, e.g. involving an experimental exercise on DNA origami. They also make a first contact to research groups at iNANO through a two-week project. In subsequent courses more advanced experimental exercises and a bigger project are carried out. In 2011 the course "Nanocharacterisation" was made compulsory to introduce a number of experimental nanoscience techniques and illustrate the use of the basic scientific disciplines taught. A course on the theory of science dedicated to the nano-area places the subject in a societal context and emphasises ethical aspects. Elective course modules at the third year of study allow fine-tuning of the course programme to the particular interest of individual students. The Bachelor's degree programme is concluded by an individual Bachelor's project.

Master's programme

During their Master's study students are required to specialize in either of three different directions: nano-physics, nano-chemistry or nano-molecular biology. Here they follow course programmes developed through individual counselling and can choose Master's courses such as "Bio-Nanotechnology", "Current Nanoscience", "Nanomedicine" or "Science-based Innovation and Entrepreneurship", offered by iNANO, as well as from a large suite of courses in the course catalogue of Science and Technology. In the compulsory 'Student's Colloquium' the students gain experience in presenting a subject of their own choice to fellow students. The specialisation courses followed on the fourth year of study enable the students to commence their one-year Master's project or alternatively to seek admittance to the PhD programme of iNANOschool.

5th year	Master project in nanotechnology		
4th year	Current Nanoscience	Specialisation	Specialisation
	Specialisation	Innovation and enterpreneurship	Specialisation
	Bio-nanotechnology	Specialisation	Specialisation
	Student Colloquia	Specialisation	Specialisation
3rd year	Bachelor project	Elective	Elective
	Bachelor project	Molecular structure	Elective
	Solid state physics	Nanocharacterisation	Elective
	Statistical physics	Fourier analysis	Elective
2nd year	Quantum mechanics	Statistics and data analysis	Advanced molecular biology
	Non-classical physics	Linear algebra	Theory of science (Nano)
	Experimental nano-project	Numerical physics	General molecular biology
	Experimental nano-exercises	Physical chemistry	General biochemistry
1st year	Waves and optics	Organic chemistry	Nano intro
	Electromagnetism		General biology
	Mechanics/thermodynamics	Inorganic chemistry	Calculus 2
	Introductory mechanics	Introductory chemistry	Calculus 1

Course programme for the interdisciplinary Bachelor's and Master's degrees in Nanoscience offered at iNANO in 2011. Each academic year (starting from the bottom) is divided into four 7-week quarters and three courses are followed each quarter.

Legend:
- **Physics courses**
- **Chemistry courses**
- **Molecular biology courses**
- **Mathematics/computer science courses**
- **Compulsory nanoscience courses**
- **Selected elective courses**
- **Specialisation modules**

GRADUATE STUDIES – **iNANOschool**

With more than 150 PhD students enrolled, iNANOschool is maintaining its position as a nanoscience graduate school of high international standing. A broad range of specialized graduate courses have been established, and iNANOschool offers student access to highly advanced research facilities. The iNANOschool provides interdisciplinary competences in nanoscience and nanotechnology at the highest international level.

Since the establishment of iNANOschool (www.iNANOschool.au.dk) in 2002, the main objective has been the education of highly qualified, internationally competitive PhDs in interdisciplinary competences within nanoscience and nanotechnology.

The research areas at iNANO and iNANOschool are highly integrated as well as truly interdisciplinary and at present cover such diverse research fields as functional nanomaterials, nanoenergy materials, nanomedicine, self-assembled molecular nanostructures, nanofood, nanophotonics and -electronics, nanotoxicology and nanoethics. Overall, the research activities are at the international forefront of science and serve as an ideal framework for education and industrial collaborations. Besides these research activities, iNANOschool offers a broad range of theoretical and practical PhD courses within nanoscience and nanotechnology and provides facilities for, and supervision of, an increasing number of PhD students. During 2011, 38 new PhD students were enrolled in iNANOschool and 40 PhD students completed their PhD studies. In addition to the focused PhD courses, activities include a major iNANO annual meeting, an iNANO Autumn School for PhD students, student networks, and initiatives to promote the exchange with other international institutions and industry.

Courses in 2011

Since 2002 an important role for iNANOschool has been to educate the students in high priority research areas and to introduce them to disciplines such as innovation, commercialization and ethical aspects of nanoscience and nanotechnology. Most PhD courses are offered as intense one- or two-week courses to ensure minimal interference to the more focused research activities.During 2011, iNANOschool offered courses in Bionanotools and Protein Structure, Science-based Innovation and Entrepreneurship, Drug Delivery and "Grand Challenges." (the topic of this year's iNANO Autumn School).

Bionanotools and Protein Structure was held on 15-19 August 2011 at Aarhus University. The purpose of the course was to introduce the students to a number of analytical techniques used for the analysis of the structure-function relationship of biological macromolecules, or biological nanomachines such as functional proteins, membrane pumps and channels. The aim of the Drug Delivery course was to provide detailed insight into theory and the more practical aspects of the delivery of nucleic acid-based gene silencing therapeutics in established cell lines, primary cells and animals. The course, Innovation and Entrepreneurship, focused on a broad knowledge of the basic concepts of innovation and entrepreneurship. In 2012 this course will be modified, forming the base of two courses Science-based Innovation and Entrepreneurship and Managing and Organizing Scientific Innovation. These courses will enable students to leverage their learning from prior courses and in novel ways provide the students with an understanding of how an organization functions. They will also learn how knowledge and methodologies from natural sciences can create innovations and be applied in a business context.

iNANO Autumn School 2011

A recurrent event in the iNANOschool calendar is the iNANO Autumn School, where all PhD students enrolled in iNANOschool are brought together for a series of workshops and different types of presentations during an extended weekend at the Danish Fuglsoecentret.

This year a new concept was developed – The iNANO Challenge. The students were divided into small teams and asked to discuss and develop an innovative solution to the many important aspects under the theme of Global Challenges. This was done to raise their awareness of these emerging challenges, and to underline the importance of Scientific Social Responsibility and ensure that the students would interact in interdisciplinary groups. Four different Global Challenges were identified, and the students were asked to discuss (and possibly come up with a solution to) the following: How can sustainable development be achieved for all while addressing global climate change? How can everyone have sufficient clean water without conflict? How can the threat of new and reemerging diseases and immune micro-organisms be reduced? How can growing energy demands be met safely and efficiently? The students were asked to discuss these problems with respect to a certain geographical region underlining the difficulties of i.e. sustainability in Asia vs. Europe or North America. On the final day of the Autumn School all groups handed in an executive summary of their solution to the problem and presented their ideas to a panel of judges and the other students.

The idea of the winning group storing sustainable energy materials in urban areas which, in turn, would be used to purify water. A highly novel idea which excited all the judges.

From the feedback given by the participating PhD students it appears that this year's topics were well chosen and highly relevant and inspirational for the PhD students. For many students it served as an eye-opener with respect to the link between solving Global Challenges and the challenging policy of how solutions may be implemented.

In addition to the iNANO Challenge, the PhD students presented their own research projects during a poster session with the intention of catalyzing discussions and stimulating collaboration among the students on their research activities.

Life after graduation – The Mentor Program

In 2010 iNANO and Graduate School of Science and Technology (The former AGSoS) launched The Science Mentor Program, with the aim of helping students in their career considerations. The mentor program offers the unique possibility to network with a mentor who has a profile matching the career dreams of the individual PhD student. The students who were enrolled in The Science Mentor Program met with their mentor several times and evaluations from both mentors and mentees indicate that the program is indeed very successful in facilitating knowledge and experience between the University and industry.

BY MICHAEL LYKKE HVAM

NANORAMA – STUDENTS ORGANIZATION

Nanorama is the organization representing the students at iNANO. The organization is run by students and was established in the spring of 2005. By arranging different social and educational activities, such as Friday lectures, the Friday bar, company visits, and an annual relay race, our goal is to make everyday life for iNANO students a great experience.

Another main aim of Nanorama is to catalyse a social network between the iNANO students from different enrolment years and to try to give the students insight into career possibilities after graduation. Nanorama tries to achieve this by arranging a number of social as well as scientific activities each year.

2011 was a great year for Nanorama, where a lot of new initiatives were launched. One of these initiatives was three Friday lectures, where scientists at iNANO gave informal lectures on hot topics within their research area each quarter. Each of the three talks per quarter covered one of the main educational areas of iNANO: nanobioscience, nanophysics, and nanochemistry. Also in 2011, Nanorama initiated a collaboration with TIMINI, our counterpart at Trondheim University (Norway), where members of the Nanorama board attended 'Buckyball', TIMINI's 5-year anniversary. In the beginning of November, a group of students from TIMINI visited iNANO and the platform for further collaboration was established. The cause of this collaboration is to create a Scandinavian network amongst nanoscience students to share good ideas; best practices and inspire each other.

In addition, Nanorama once again attended the annual Aarhus 1900 relay race, arranged Friday bars and held our INANO birthday party. We also conducted the traditional end-of-the-year day with social activities, where students could meet each other one last time in a relaxed atmosphere before leaving for the summer break. In the beginning of the autumn semester we organized a social weekend primarily for the students who have been at iNANO for a couple of years. This was a great success where students from the different year groups had a chance to further socialise and meet new friends.

The current Nanorama board's election period last until the beginning of 2012, and several events have already been planned. Among these, a 'short-term-exchange' with TIMINI, where we will exchange 15-20 students for a few days. The purpose is to give the students insight into how nanoscience is taught elsewhere and to encourage friendships between the students of Nanorama and TIMINI.

To provide the students with awareness of the possibilities after they graduate at Aarhus University, Nanorama have planned a number of events in 2012. We will repeat the successful social weekend between senior classes, we will organize talks in collaboration with professional organizations, and we will continue to develop new initiatives in our endeavor to reach all students and to create the best possible social network for the nanoscience students at iNANO.

STUDENT **CONFERENCES** – AT ALL LEVELS

During 2011, iNANO was involved in two student conferences, namely the International Nanoscience Student Conference, INASCON, targeting undergraduates and the UNF summer science camp aimed to inspire high school students.

INASCON 2011 organizing committee.

INASCON 2011

INASCON, International Nanoscience Student Conference, is a four-day conference intended to promote networking between nanoscience students from all over Europe at an early stage of their scientific careers. INASCON is unique in the sense that it is arranged by and targeted only at students, whereas other conferences usually focus on the work of well-established scientists. For the majority of the participants, INASCON is their first encounter with a real conference.

At INASCON 2011, exciting talks were given by six internationally renowned scientists: Liv Hornekær, Yi-Yeoun Kim, Stig Helveg, Jean Pinson, Mathis Riehle and Richard Douthwaite. The programme furthermore consisted of dissemination talks, company sessions, student talks, poster sessions, team building and other social activities.

INASCON 2011 was made possible thanks to generous contributions from several different foundations or companies. The biggest contributors were Tuborgfondet; the Danish Society of Engineers (IDA); the Danish Agency for Science, Technology and Innovation; Lundbeckfonden; iNANO and Graduate School of Science and Technology, Aarhus University.

We look forward to INASCON 2012, which will be arranged by students from Saarland University, Germany.

UNF NANO CAMP

The Danish Youth Association of Science (UNF) is an organization for people with a particular interest in science. The purpose of UNF is to promote science to youth and give already interested youth an opportunity to gain insight into today's science.

In 2011 iNANO hosted a UNF summer science camp focusing on nanoscience with 25 participating Danish high school students. The participants and UNF volunteers spent a week of their summer holiday at Aarhus University, where they also ate and slept. The camp was arranged by UNF volunteers with the help of the scientific staff at iNANO. The scientific focus of the camp was to show the interdisciplinarity of nanoscience. This was done through ten lectures, three laboratory exercises, a visit to Danisco and a nanoshow. This programme meant that the participants were introduced to AFM microscopes, DNA origami, nanoscience history, the ethics of nanoscience and much more.

At the end of the daily scientific program, different social activities were planned. These included an orienteering around the university park, a trip to the bowling alley, fun at the university lake with funballz and a costume party.

INTERNATIONAL STUDENT ACHIEVEMENTS

In 2011 a number of young, extremely talented iNANO students received international recognition based on either incredible work performed during e.g. their Bachelor's or PhD projects or from winning competitions – all on the competitive international scene.

Every year the organization Euroscience – a European association for the promotion of science and technology – hands out 'the European Young Researchers' Award". The award is given to a young researcher from any field of science who has demonstrated outstanding research performance.

The Euroscience Selection Committee unanimously decided to grant the European Young Researchers' Award 2011 to Dorthe B. Ravnsbæk from Center of Materials Crystallography, iNANO. The selection committee emphasized the exceptional scientific quality and the high level of European collaboration in Dorthe's research demonstrated by a large number of peer-reviewed papers and oral presentations at conferences. Furthermore, Dorthe was judged an inspirational team worker with great communication qualities. The award ceremony will take place in July 2012 during the EuroScience Open Forum conference in Dublin, where Dorthe will give a talk on her research.

The aim of Dorthe's research is to develop new materials for storing hydrogen, so that hydrogen can be used efficiently and safely as carrier of sustainable energy in future mobile applications. More specifically, Dorthe has synthesized a wide range of novel metal borohydrides with high hydrogen storage capacities, and studied trends in crystal structures, hydrogen storage properties and reactivity of these novel compounds. After obtaining her PhD degree in October 2011, Dorthe is now a postdoc at CMC, however, from March 2012 she will be moving to a postdoctoral position at MIT. Here, she will keep on working within the field of energy storage, though she will shift her focus from hydrogen to Li-batteries.

"I am very honored and also quite overwhelmed to have been rewarded this prestigious award. It is a great acknowledgement, not only of me and my work, but of all my colleagues here at iNANO. It shows that we are carrying out science at a very high level. No one can make great science alone, so I am of course very grateful to all my co-workers at the Department of Chemistry and especially to my PhD supervisors Associate Professor Torben R. Jensen and Professor Flemming Besenbacher.

The award also sparked a flurry of interest from the Danish media. This is something I, as a scientist, is not really accustomed to, but dealing with this kind of attention has been very educational, and it has given me many opportunities to promote my research and science in general to a very broad audience. I hope that I have helped to brand iNANO and Aarhus University in a positive manner.

There is no doubt that receiving the European Young Researchers' Award will open a lot of doors for me in my future carrier. Already I have been fortunate to receive a grant from the Carlsberg Foundation allowing me to get into MIT, which is really a dream come true."

Dorthe B. Ravnsbæk

The design of a new RNA-based nanodrug lead a team of iNANO Bachelor's students to victory at Harvard University

Since 2006 the design and creation of two- and three-dimensional structures using programmed self-assembly of DNA has been a hot topic in nanoscience. Against this background the Wyss Institute for biologically inspired engineering at the prestigious Harvard University has started a competition in biomolecular design called BIOMOD. During the summer, 21 teams from all over the world worked hard to design and assemble their own functional biomolecules, and on 5 November 2011 all the teams went to Boston to present their work to a panel of internationally recognized experts.

The iNANO team, named Danish Nano Artists, consisted of five Bachelor's students: Jens Vogensen Biasevich, Mie Elholm Birkbak, Irene Maria Hansen, Hans Christian Høiberg and Steffen Lynge Sparvath. They carried out their work in the laboratory of Professor Jørgen Kjems, aided by their mentors: Ebbe Sloth Andersen, Mette Jepsen, Anders Okholm and Rasmus Schøler Sørensen.

The judges awarded the team with the prize for best presentation, as well as the Grand Prize for the best overall project.

The team presented a novel approach to drug delivery, in which the drug carrier can serve as a drug by itself. The team folded a strand of RNA, a molecule that is normally used to carry information in the cell, into a three-dimensional structure. This structure was created in a way so that it, upon entering the cell, is broken down into small pieces called siRNAs that regulate the expression of certain specific genes. This could be used to combat the expression of genes related to certain diseases.

Euspen is the European Society for Precision Engineering and Nanotechonology

Each year, a challenge is held for European students within these fields. In 2011, iNANO PhD student Lasse Bjerg participated, and his team ended up winning the challenge.

During spring 2011, national competitions were held in nine European countries. From these, three participants from each country were selected for the international final held on 26-29 July 2011 at Cambridge University. Nine mixed teams were created the first evening, and the challenge, which had been unknown until then, was presented to the teams. The challenge was to develop a prototype of a device which can aid blind people ascending or descending a set of stairs, using a limited set of electronic and optic components. The winning team produced a very simple, but very reliable device, reminiscent of a car parking sensor, to be integrated into the shoes of the blind person. Having only three days to come up with a solution, and to build a working prototype, is very different from the long-term PhD project.

However, the innovative thinking required for such a challenge can also be used in the daily work of a PhD student. iNANO, therefore, encourages its students to participate in challenges.

BY KARTHIGA PANNEERSELVAM,
KASPER MONRAD, PELLE GARBUS
AND MADS ØSTERGAARD,
iNANO BACHELOR'S STUDENTS

TUBORGFONDET

THE ANNUAL **STUDY TOUR**

In 2011, as in previous years, iNANO students who had just finished their second-year nanoscience studies went on an international study tour, seeking inspiration for their continued nanoscience studies and hoping to gain insight into the scientific environments at some of iNANO's international scientific partners. This year's destination was the inspiring nanoscience environment of England.

This year the study trip went to England, more specifically the universities of Cambridge, Bristol and London.

On the 20 June 2011 the scientific programme began with a visit to the Cambridge Nanoscience Centre at University of Cambridge, which is an interdisciplinary centre much like iNANO. We met with Director and Professor Mark Welland and his scientific staff, who introduced us to various research projects being performed at the centre.

After a short lunch we were shown and allowed into the magnificent clean rooms and saw their various research equipment. Before going back to London, we visited the campus area and had dinner at the historically significant pub, The Eagle, wherein Watson and Crick initially had their groundbreaking idea about the structure of DNA.

The following day we went to Bristol to visit the Bristol Centre for Functional Nanomaterials at University of Bristol. We were given a tour of the centre by the Director Dr. Terry McMasters and saw the unique architecture of the centre: the affiliated departments are easily accessible yet vibrationally disconnected, making it a proper working environment for exact measurements, and the architecture inspires researchers to work more interdisciplinary. In the afternoon we had our first experience with a real poster session, which was a pleasant and enlightening experience.

At the third and last day of the academic programme we visited both the London Centre of Nanotechnology (LCN) at the University College of London as well as Imperial College. At LCN we were split into groups and were given a guided tour of the facilities along with introductions to their research projects. We were surprised to find out that they do not share our belief in the Copenhagen interpretation. After lunch we took the tube to Imperial College and toured their facilities, where we were given a brief introduction to their famous TITAN TEM.

All in all, we had a very educational trip, which was also highly entertaining and fun.

This trip was made possible by grants mainly from H.C. Holsts and the Tuborg foundation. A special thanks to Leif Schauser for helping with the fundraising and Associate Professor Duncan Sutherland for organizing and participating in our study trip.

SAFETY FIRST: **CARBON MONOXIDE** AS A HARMLESS **NANOPOWDER**

The inventing team and the four founders of SyTracks: Troels Skrydstrup, Anders Lindhardt, Thomas Gøgsig and Rolf Taaning.

The toxic gas carbon monoxide can now be provided as a harmless nanopowder and handled safely in any fume hood or chemical facility. This innovative achievement has resulted in the spin-out company SyTracks, which intends to revolutionise the way industrial chemists and scientists use carbon monoxide.

New chemical transformations are developed on a daily basis in order to allow chemists to synthesise novel chemical compounds and improve the production of existing ones. Such chemical recipes are of vital importance to society because they facilitate the development of new applications in the pharmaceutical, agrochemical, or chemical industries and also lead to cost reductions within these sectors.

Chemical transformations with carbon monoxide fit the above-mentioned description and the utilization of this small chemical building block has experienced a renaissance during the last decade. By including carbon monoxide in organic synthesis, manufacturers are often able to limit the number of steps required in a sequence towards the target molecule. This enables more efficient industrial production of drugs, chemicals, polymers and other consumables.

Obvious safety concerns

Although carbon monoxide is an exceedingly versatile reagent it does have serious drawbacks due to the inherent properties of the gas. When inhaled carbon monoxide binds to haemoglobin in the bloodstream outcompeting oxygen and this may lead to asphyxiation and ultimately death. In addition, carbon monoxide is flammable, and since it is a colourless, odourless, and tasteless gas, gas-detectors must be installed in order to protect the workers. Nevertheless, the benefits of using carbon monoxide in chemical synthesis are so large that several industries apply tons of the gas.

Until now, the only carbonylation equipment available to the chemist is the classical pressurized canister and more specialized equipment capable of handling the dangerous gas at high temperatures and pressures. For small-scale purposes in research and academia carbon monoxide is often avoided due to the obvious safety concerns. Thus, safe solutions avoiding direct handling of the gas are highly desirable.

Controlled release from nanopowders

While working on a research project in which carbon monoxide was essential, we experienced all these worries and soon became interested in changing the way this potentially dangerous gas may be handled.

In previous work we had found that carbon monoxide was partially produced during the activation of a catalyst by applying simple acid chlorides. With this discovery in mind, we set forth to investigate the new carbon monoxide source and its potential applications. Our work led to the development of the stable, easy to handle, and safe nanopowders, COgen and SilaCOgen. Carbon monoxide can be released from these powders in a highly controlled low-pressure manner by using palladium catalysis and an exact amount of the gas can be produced by simply weighing out the desired amount of COgen or SilaCOgen.

Direct handling is avoided

Furthermore, we have devised a two-chamber system called COware that has proved to be ideal for carbonylation chemistry.

The system consists of one chamber for the production of carbon monoxide and an additional chamber for the carbon monoxide consuming reaction. The two chambers are connected by a gas bridge and this design ensures that the toxic gas never leaves the system during chemical synthesis. In this way direct handling of carbon monoxide is avoided. COware fits into any fume hood allowing everybody to perform carbon monoxide chemistry. In fact, this new technology provides modern chemists with a safe and easy-to-handle tool greatly improving workflow flexibility.

Rapid commercialisation

Since our discovery of the nanopowders in 2010, two patent applications have been filed and in 2011 the project received a DKK 220, 000 grant from Aarhus University to assist the commercialization of the invention. Since then collaborations have been set up with the pharmaceutical company AstraZeneca and with PET-centres in Aarhus and in Uppsala, Sweden, in order to establish the viability of the technology in different fields.

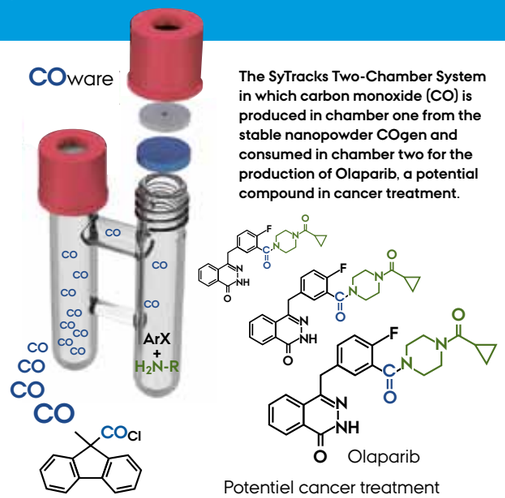
Finally, in collaboration with Aarhus University and the Technology Transfer Office the inventing team launched the spin-off company SyTracks A/S in September 2011. The company will assist laboratories in implementing new carbon monoxide solutions, deliver custom-designed carbonylation equipment, and perform contract research. SyTracks is devoted to safe and simple carbon monoxide solutions suitable for any working environment and for any carbon monoxide purpose.

Special thanks goes to the fantastic co-workers in Troels Skrydstrups group, the workshop (Eigil Hald , Palle Kjær Christensen and Erik Ejler Pedersen), the glassblower (Jens Christian Kondrup) and the Department of Chemistry, Aarhus University. Without their help, input and fruitful discussions this project would never have made it this far.

Carbon isotope labelling made easier

The amount of carbon monoxide applied in complex chemical reactions can be controlled with high precision using nanopowders. This makes our technology ideal for carbon isotope labelling. Typically a rare carbon isotope is installed into a molecule in order to trace how the labelled compound behaves on its way through a biological system such as the human body or in nature.

Building isotopes into complex molecules is a very delicate and costly process. However, with the novel nanopowder technology the carbon isotope can be installed at an advanced stage of the synthesis. This provides an attractive method for labelling in combination with the application of minute amounts of carbon monoxide.



The SyTracks Two-Chamber System in which carbon monoxide (CO) is produced in chamber one from the stable nanopowder COgen and consumed in chamber two for the production of Olaparib, a potential compound in cancer treatment.

COgen and SilaCOgen are both stable solids at room temperature and hence they are very easy to handle.

BY HENRIK BIRKEDAL

INSPIRED BY MUSSELS: **WOUND SEALANTS** AND **SELF-HEALING** MATERIALS

No man-made glues work well under water or in watery environments such as blood. Mussels in the sea, however, are able to stick to almost any material. Studying their glues may lead to a multitude of biomedical applications such as wound sealants, which may replace suture in surgery, and smart materials that can glue together any two surfaces underwater and imbue the resulting bond with self-healing properties to protect the joint from wear and tear.

Gluing things together is an everyday task that most of us take for granted, but actually we are not able to glue all the objects we would like to. Gluing is especially difficult when things are wet; essentially no man-made glue works underwater.

An example of difficult gluing is wound sealants, if effective they would obviate suture in surgery. Mussels on the other hand stay comfortably stuck using glues that work underwater and on a huge range of substrates. The blue mussel for example can attach itself to almost anything. Therefore, we study mussel attachment and develop mussel inspired glues that are likely to lead to a multitude of future applications.

The blue mussel can adhere to almost anything.

The glue of the blue mussel

The glue of the blue mussel is made from proteins with a dash of metal ions added to the pot. The proteins are rich in an amino acid called DOPA, which bind metal ions very strongly, in particular iron. The way the glue works depends on the pH of the solution. At low pH, below that of vinegar, only one DOPA is bound per iron ion. At medium pH, two amino acids are bound per ion while at higher pH each iron ion binds three amino acids. The beauty of DOPA/metal bonds is that they are reversible so once broken they can reform. Therefore, a material utilising these bonds may be self-healing; if a tear occurs, it can repair itself.

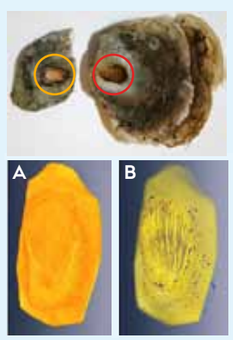
Underwater adhesion – hanging on by a thread

The mermaid's toenail, Anomia simplex, attaches itself to its living quarters with an anchor that extends through a hole in one of the shells. We have studied the design, mechanics, and chemical properties of the anchor to unveil new principles for how to make underwater adhesives.

The anchor is over 90 per cent mineral by weight. The rest is organic materials that act as glue between anchor and substrate, as interface between musculature and anchor and as an important part of the anchor itself.

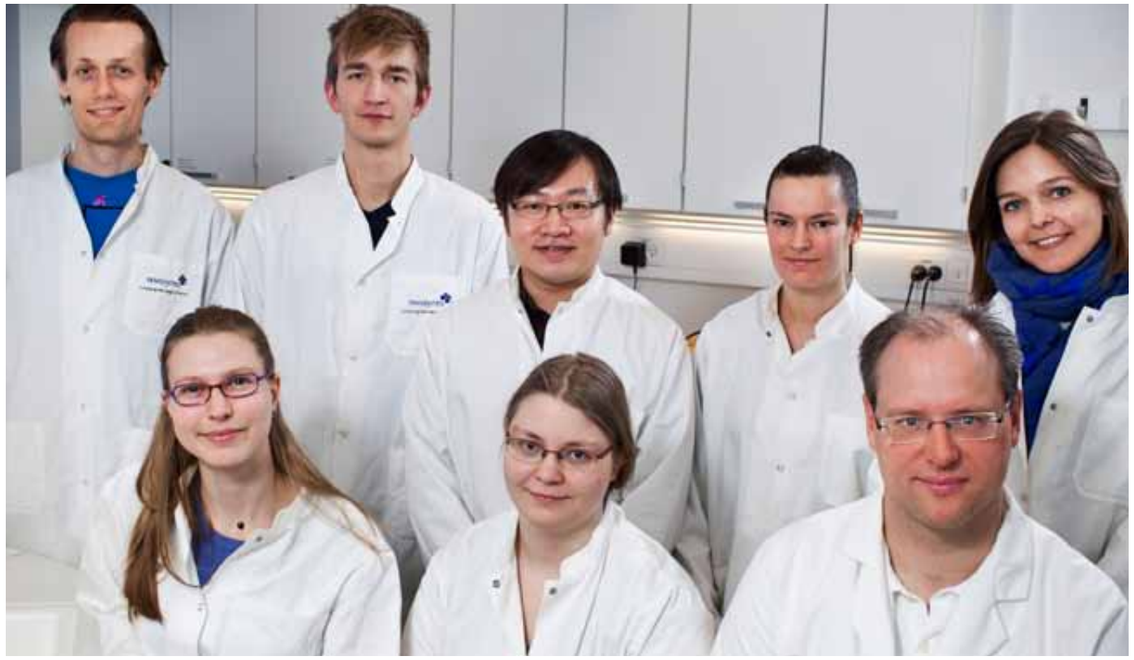
The mineral in the anchor is chalk ($CaCO_3$). The organic phase is a mixture of the sugar chitin, known from the carapaces of crabs and lobsters, and proteins. By combining these materials, the animal obtains just the right combination of softness provided by the organics and hardness from the crystalline mineral to tune the mechanical performance of the anchor.

This impressive feat is achieved by placing the nanosized building blocks in a hierarchical structure. We still do not know exactly which molecules are involved in gluing the anchor to the substrate, but we surely hope to reveal that.



The mermaid's toenail sticks to underwater surfaces with a mineralized byssus (marked in gold) extending through a notch (marked in red) in the bottom shell.

Micro-computed tomography – CT – shows the surface (A) and interior structure (B) of the byssus, including a large number of pores shown in blue.



The mussel team: Rudi Stallbohm, Simon Frølich, Yao Hung Tseng, Hanna Leemreize, Marie Krogsgaard, Tea Søe Knudsen, Vicki Nye and Assoc. Prof. Henrik Birkedal.

Harnessing mussel chemistry

To harness this mussel chemistry, we make polymers that have DOPA affixed to them with chemical bonds. Mixing these polymers into an acidic solution containing iron ions results in a green liquid. By adding base, the colour changes from green to blue and the liquid becomes viscous. The addition of even more base makes the sample deep red, almost black, and turns it into a gel with a consistency reminiscent of jelly. This gel can be shaped as desired, flows out very slowly, and most excitingly, it can heal itself. When a tear is made in the material, it spontaneously repairs the damage.

We have developed improved polymeric systems that provide even better control over the self-healing properties and they are currently being patented. We expect these self-healing materials to find a wide range of applications in the biomedical field. We are also exploring their adhesive potential. Our vision is to make mussel-inspired materials capable of gluing together any two desired surfaces underwater and imbue the resulting bond with self-healing properties to protect the joint from wear and tear.

Self-healing within minutes

The mussel-inspired DOPA functionalized polymers are held together by coordination chemistry bonds between the amino acid and the metal ion. These bonds are almost as strong as covalent chemical bonds.

Contrary to covalent bonds, however, they can reform when broken because the DOPA molecule can simply find another metal ion to bind to. Therefore materials based on these bonds can be self-healing. We have investigated the healing process by dynamic rheology, where we apply strain on the material until it breaks, relieve the strain, and follow the reappearance of the material strength.

Our present molecules heal very rapidly, within a few seconds. If you cut a lump of the material in two and put the parts back together, they stick almost immediately and any sign of the cut has disappeared after 45 minutes.

**Selfhealing:
Cut it.
Put it back together.
And watch.
Soon the material is healed.**

GETTING STUCK – HOW **BACTERIA** FORM **BIOFILMS** AND HOW TO **PREVENT** IT

Bacterial biofilms are the main cause of persistent infections and are highly tolerant to antibiotics. Therefore, it is of great interest to forestall the formation of biofilms through the development of antibacterial surfaces. Ideally, these surfaces should be free of biocides that may cause resistance, and they should therefore prevent attachment rather than killing the bacteria.

Our perception of microbial life was fundamentally altered when it was discovered that most bacteria do not live as free-swimming cells in suspension, but as encapsulated microbial communities attached to surfaces. These bacterial biofilms are found everywhere and they affect our daily life in numerous ways. Biofilms may cause cavities in our teeth, infections in our body, and spoilage of food when they form on equipment used in food production.

Life in a biofilm provides protection from predators, biocides, antibiotics, and even from the human immune system, and this makes it particularly difficult to eradicate bacteria in biofilms. Thus, the Holy Grail in biofilm control is to develop strategies that target the formation of biofilms, rather than their subsequent removal.

Anti-bacterial surfaces often depend on the release of biocides or antibiotics, which kill bacteria that come into contact with the surface. However, killing bacteria may result in selection for resistant strains. Ideally, the formation of biofilms should be prevented by intercepting crucial steps in their development such as the attachment of the bacterial cell to a surface.

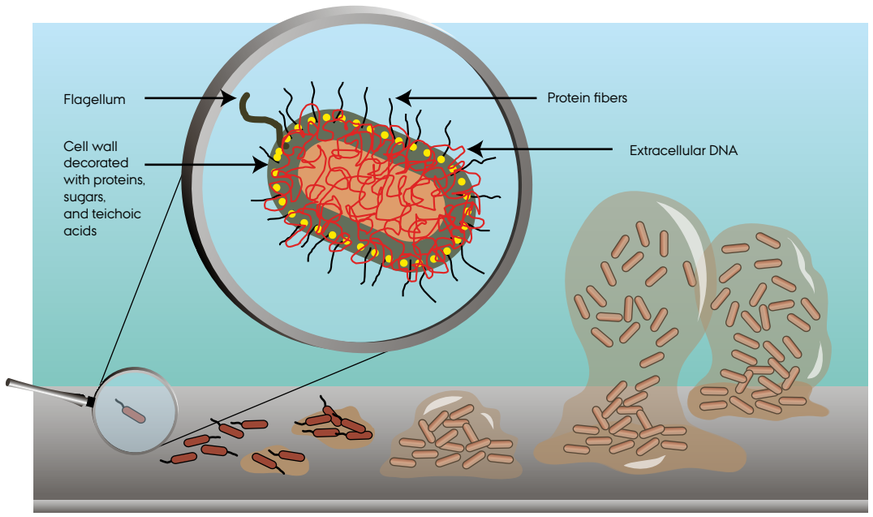
Surfaces may forestall attachment

With the advent of nanotechnology, the structure and chemistry of surfaces can be controlled with unprecedented accuracy, and this opens new avenues for the design of surfaces that are not anti-bacterial but anti-biofilm in the sense that they do not kill bacteria but merely prevent their attachment.

The development of anti-biofilm surfaces requires a detailed understanding of the biological mechanisms applied during bacterial cell attachment. In other words, we need to understand what makes bacteria stick in order to prevent them from doing so. In 2011, my group was awarded an DKK 8.6 million Sapere Aude Starting Grant from the Danish Council for Independent Research to address this fundamental question: How do bacteria stick to surfaces?

In search of the bacterial anchors

A curious observation is that bacteria are not really sticky as such. The key to explain why bacteria are so successful in adhering to surfaces everywhere is specialized biomolecules that form nanoscale structures on the surface of the bacterial cell. These biological anchors are called adhesins.



A biofilm is built in several steps

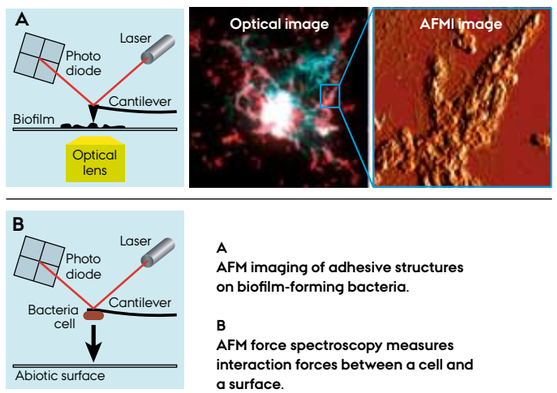
First, bacteria encounter a surface and attach to it, and the cells rely on nanoscale extracellular structures to do this. After attachment, they excrete polysaccharides and other biopolymers that form the extracellular matrix, which provides structural stability to the biofilm as it grows into a three-dimensional "city of microbes". Our work focuses on understanding how a cell attaches itself to a surface and starts a biofilm.

Assoc. Professor Rikke Louise Meyer.

Through their production of adhesins, bacteria are able to control when and – to some extent – to what they attach. Our aim is to identify bacterial adhesins, and to investigate how they work and how their production is triggered by environmental cues.

DNA as universal glue

We explore bacterial genomes in order to identify new adhesins, and we also study adhesins that we and others have already identified as being important in bacterial attachment. One of these is DNA, which was rather surprising when first discovered. As most people know the core function of DNA is to store genetic information. But when DNA is outside a bacterial cell, this long and stable biomolecule provides structural stability to biofilms and aids in the initial attachment to a surface. This phenomenon has been observed for many different species of bacteria, and our research indicates that extracellular DNA is a kind of "universal glue" that attaches bacteria to almost any type of material. We are currently addressing the question of how this peculiar glue works.



A
AFM imaging of adhesive structures on biofilm-forming bacteria.

B
AFM force spectroscopy measures interaction forces between a cell and a surface.

Biofilm formation at the nanoscale

The surface properties of bacteria in a biofilm vary considerably from cell to cell and even across the surface of a single bacterium. Therefore, it is necessary to locate and measure the adhesive properties of specific cell surface structures at the single-cell and single-molecule levels.

This makes the toolbox of nanotechnology particularly important. We use Atomic Force Microscopy (AFM) to visualise the surface of living bacteria with nanoscale resolution and combine AFM with fluorescence microscopy in order to identify specific adhesins and label these molecules simultaneously. AFM can also quantify cell-to-surface interactions with great accuracy by measuring the attractive and repulsive forces at play when a single bacterial cell comes into contact with a surface.

Our objective is to gain a better understanding of how bacteria use specific adhesins to attach to surfaces and form biofilms. By doing so, we lay the foundation for developing surface materials capable of preventing the formation of biofilms by blocking the interactions between bacteria and surfaces.

A
Atomic force microscopy (AFM) is used for high-resolution imaging of extracellular adhesive structures of biofilm-forming bacteria. In combination with fluorescence microscopy, the structures can be identified by fluorescence labeling. In the optical image, bacteria are shown in red and adhesive fibers (cellulose) are cyan.

B
AFM can furthermore measure the interaction forces. We immobilise bacterial cells to the tip of the cantilever, and measure the attractive or repulsive forces between the cell and the surface as they approach each other.

DEVELOPMENT AND APPLICATION OF **DNA-BASED NANOROBOTS**

DNA strands can be designed to self-assemble into custom-built nanoscale shapes. The most advanced constructs are called nanorobots since they can sense, compute, and act upon stimuli from their environment. We aim to develop nanorobots capable of detecting complex mixtures of chemicals or biomolecules and apply these sophisticated DNA devices in sensors and smart nanomedicines.

The research field of structural DNA nanotechnology was initiated more than 30 years ago and has been developing steadily. However, a main game changer came with the introduction of the DNA origami method by Paul Rothemund, who demonstrated an unprecedented ability to control the shape and patterning of large DNA complexes. The initial breakthrough was followed by the development of software for computer-aided design (CAD) that facilitates the design of three-dimensional DNA origami structures. Researchers now use DNA origami to organize other nanomaterials, which could lead to applications in medicine, electronics, biophysics, and molecular robotics.

A nanorobot is a nanomechanical device that senses, computes, and acts accordingly. The original vision was to make miniature versions of electronic robots performing mechanical work, but surprisingly DNA can now be applied as construction material for nanorobots that respond to clues in their environment. An example is a DNA box developed by us. The DNA box senses precise combinations of biological signals and opens its lid to release a payload. Other DNA-based nanorobots can walk on tracks, manufacture a range of products from a DNA assembly line, or target and kill cancer cells.

The research group is established based on a Sapere Aude Starting Grant of DKK 8.6 million from the Danish Council for Independent Research, Technology and Production Sciences. The laboratory will focuses on the design, production, and application of DNA-based nanorobots and the laboratory will be equipped with CAD tools as well as systems for sample handling, assembly, purification, and testing. The aim is to develop, test, and optimize sensing, computing, and acting elements that can be assembled into reliable high-quality nanorobots built from DNA.

Design of nanomechanical devices
The structural part of a nanorobot is designed using molecular CAD software and DNA origami self-assembly strategies. When we want to construct a nanomechanical device with both rigid and flexible parts, the structure is thoroughly investigated using simulation software before the first experiments. The blueprints for a nanorobot are typically designed in a modular fashion, which enables many versions of the device to be assembled and tested. The structural quality of these variants can be examined by several biophysical techniques including Atomic Force Microscopy (AFM), Small Angle X-ray Scattering (SAXS), and cryo-electron microscopy.

Development of sensor modules
To enable the nanorobot to sense its environment, we develop sensor modules with adaptor sequences to attach them to the nanomechanical device. An example of a simple sensing module is the locks and keys used for opening the DNA box, which are based on complementary single strands of DNA that combine to form a double helix. Now we develop several new lock systems based on DNA or RNA sequences that recognize chemical compounds or proteins.

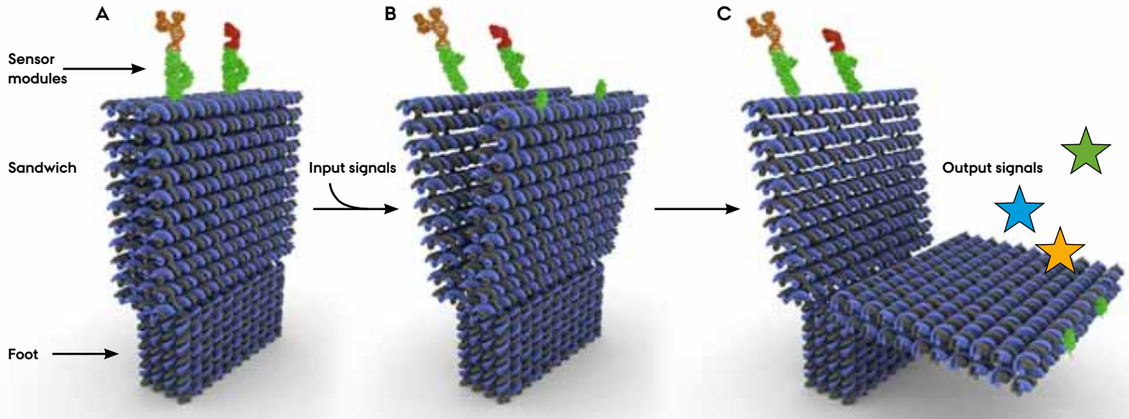
Building a molecular computer
A key challenge is to make the nanorobot compute. Here we take advantage of recent progress in the fields of DNA computing and molecular programming that makes it possible to implement mathematical logic in circuits based upon molecular inputs and outputs. An example of molecular computing is when the output of a nanorobot depends on several sensor modules, which reacts as AND, OR, and NOT gates in different combinations. Another example is cancer diagnostics, where nanorobots may detect very specific combinations of messenger-RNA signals that are precise markers for different types of cancer. Several multi-signal sensor devices will be designed with specific purposes in mind and tested both in the laboratory and in animal models.

Diagnosis and intelligent drugs
Many applications can be realized if we succeed in engineering high-quality nanomechanical devices that can compute, sense, and act. Already, a medical nanodevice that senses disease signals and releases a drug has been demonstrated for cancer cells. However, by developing more sensor modules and testing them for different medical applications, it will become evident how far this technology can be applied.

Our hopes are high because DNA origami structures can be modified with protecting molecules that prevents the degradation of DNA in the blood stream and equipped with targeting molecules enabling the drug to reach its specific target in the body. Another advantage is that DNA nanorobots are biodegradable since they are mainly made of biomolecules. The ultimate goal with such medical devices is to imitate the capabilities of a virus particle. This is because a virus is simple – just a core of genes inside a protein coat – but even so capable of entering cells and exploiting their biochemical machinery to its own end.

Another promising application is environmental or industrial sensors. For such devices the scientific and practical challenges will depend on the harshness of the actual environment. Nevertheless, we firmly believe that the possible applications will be numerous if we succeed in the engineering of robust, reliable, and efficient DNA nanorobots.

Steffen Lynge Sparvath, Anders Okholm, Assistant Professor Ebbe Sloth Andersen and Denis Selnihhin.



An example of a simple nanorobot
A The nanomechanical DNA origami device is composed of a foot and a sandwich of DNA sheets held together by two sensor modules at the top.
B Upon binding two input signals the sensor modules unlock and the nanomechanical device opens.
C The opening exposes an output signal, e.g. a new biomolecular signal or fluorescent light.

DNA origami model by Ebbe Sloth Andersen, rendering by Niels Vinther Voigt.

BY PHILIP HOFMANN

FOR REAL AT LAST: **NANOSCALE SPINTRONICS** AT ROOM **TEMPERATURE**

Serious progress in information technology requires going beyond the established route of designing ever smaller components. Recently, we have discovered a novel material that could allow the realization of the groundbreaking idea of nanoscale spin transistors that work at room temperature. This may lead to the development of a new generation of ultrafast and energy efficient chips based on spintronics.

The last time electronics was reinvented was back in 1948 when Bell Laboratories in the USA presented the transistor to the public. Soon the bulky vacuum tubes of the past were outcompeted, and the transistor paved the way for the microelectronics revolution. Still today, virtually all electronic devices are based on transistors that work by regulating the flow of electricity in a semiconductor with the help of a small external voltage.

We may now be on the verge of the next revolution in information technology. For decades, researchers have been trying to utilise another fundamental property of electrons – their spin – rather than their electric charge. This technology is called spintronics, and it may lead to the development of extremely fast chips with very limited energy consumption.

However, until now the goal has been elusive and it has only been possible to build spin transistors that work at temperatures around minus 270°C, which obviously makes them unsuitable for everyday electronic devices. Finally, change has come. In a recent breakthrough we discovered that bismuth selenide enables the construction of nanoscale spin-field-effect-transistors that work at room temperature.

A new spin on topological insulators

The main reason why it has been so difficult to construct spin transistors is that the spin effect is miniscule. Thus, the electrons have to cover long distances to enable rotation of their spin by a reasonably small electric field. We have discovered that the semiconductor bismuth selenide solves this difficulty, because it is capable of generating a spin effect that is more than a hundred times stronger than other semiconductors, permitting a corresponding reduction of either the field strength or the path length of the electrons. What is more, bismuth selenide could make the spin transistor work at room temperature! This sets the stage for the development of spin transistors that perform at relevant temperatures and right down to the nanoscale, which could lead to the introduction of spintronics in everyday devices in our homes and workplaces.

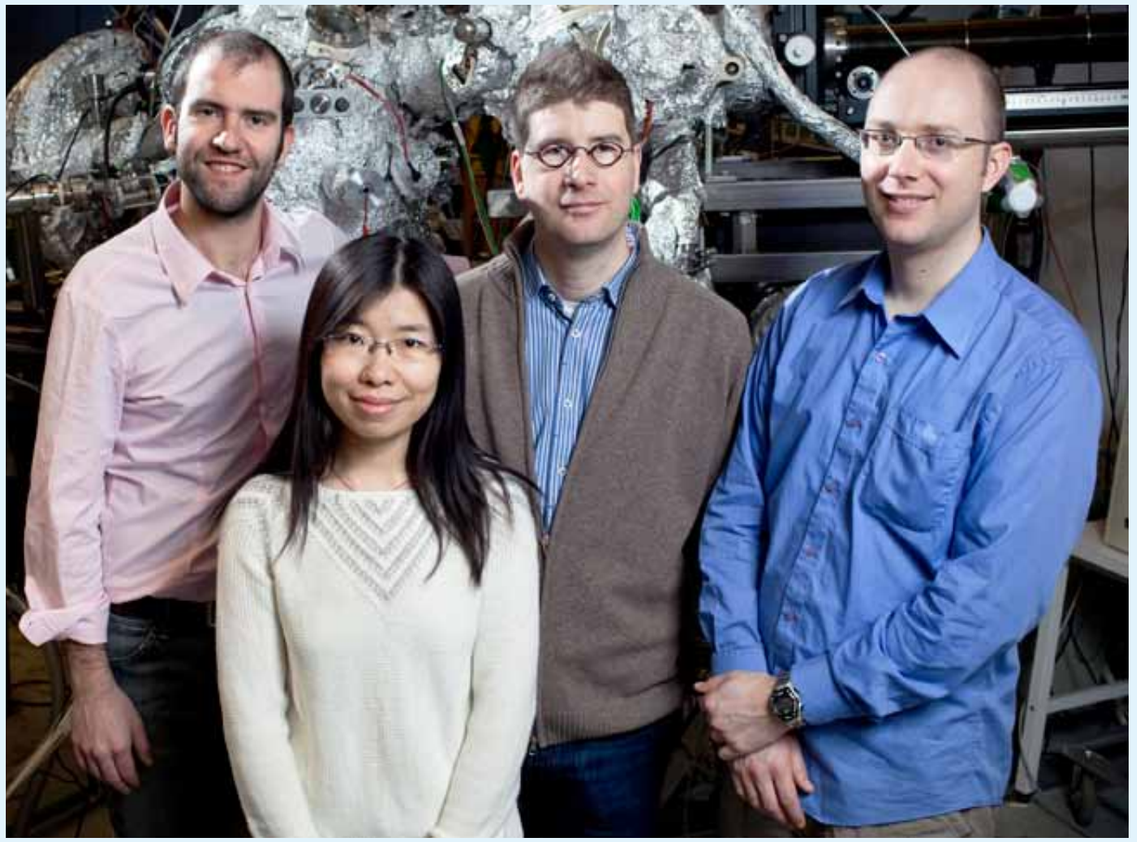
Like many other scientific discoveries throughout the course of time, this new property of bismuth selenide was discovered by chance. Recently, bismuth selenide has been studied in detail because it is one of the few known topological insulators. These novel materials insulate on the inside, but conduct on the surface. They may have many fascinating applications, from thermoelectric materials to spintronics and quantum computing.

However, the recently discovered spin effect is not actually related to the properties of bismuth selenide as a topological insulator. It just appears that nobody had discovered this unique quality until now or at least not recognized its significance.

Fast and energy-efficient computers

Transistors based on spintronics could enable faster and more energy efficient processors for computers. In fact, electronics as we know it has reached a point where progress is slow and only takes place in small steps. Therefore, a new paradigm is needed.

Scientists around the world have several interesting theoretical ideas for new directions such as the revolutionary quantum computer, but we do not yet possess the materials necessary to implement them. Spintronics too has a long way to go before becoming commercial, but with the rapid development taking place in research this may happen sooner than anyone would dare to predict.



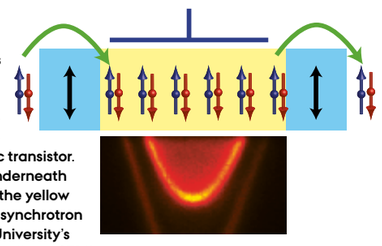
Marco Bianchi, Dandan Guan, Philip Hofmann, Richard Hatch.

A different breed of transistors

Electronic microchips rely on electricity while spin transistors utilise the rotation of electrons, which is called their spin.

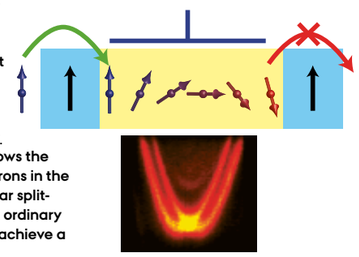
Electronics

Current electronics is based on field effect transistors (FETs) consisting of two electrodes (light blue) on either side of a semiconducting material (yellow). The flow of electricity through the transistor can be controlled by applying a small voltage on the gate electrode at the top (dark blue), which attracts electrons and enables conduction. This is used to shift digital bits by turning the current on and off. The spin of the electrons, symbolized by arrows, is unimportant in an electronic transistor. The coloured image underneath shows the electrons in the yellow channel, measured by synchrotron adiation from Aarhus University's synchrotron radiation facility, ASTRID.



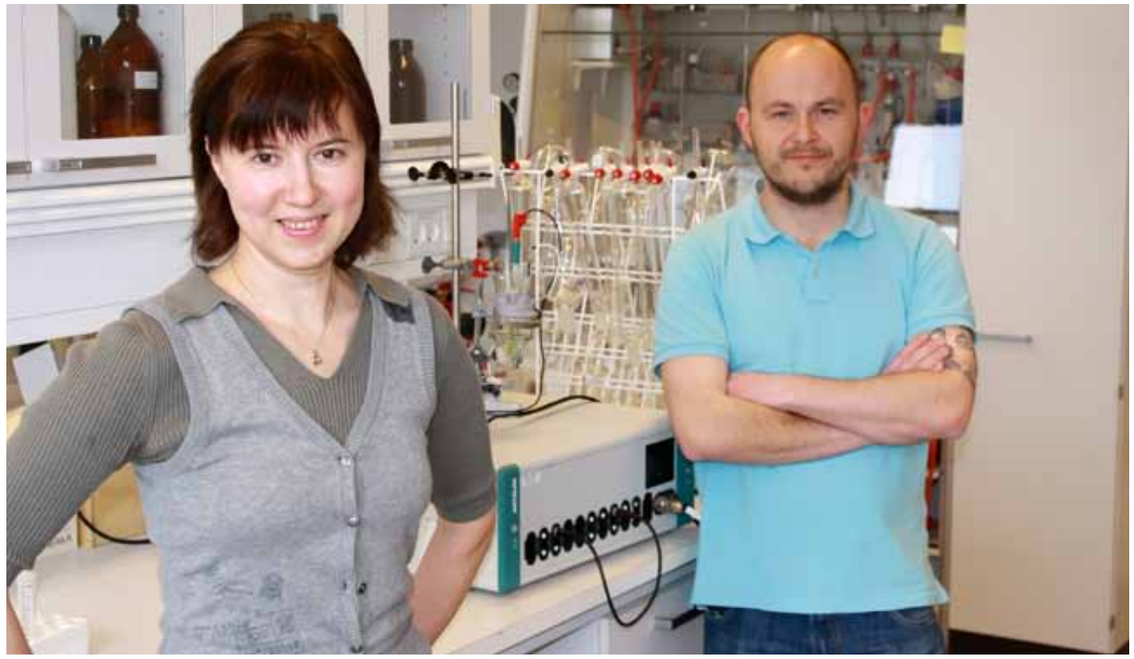
Spintronics

In a spin-FET all the electrons are spin polarised when they are delivered from the left electrode to the yellow channel. This means that their spins are either up – as chosen in this figure – or down. A small charge on the dark blue gate electrode leads to a rotation of the spin as the electrons move through the transistor. When the spin is not altered, the electrons can enter the right electrode, but when the spin is rotated they cannot. This decides whether the bit is 1 or 0. The coloured image shows the distribution of the electrons in the yellow channel. The clear splitting compared with the ordinary transistor is required to achieve a spin rotation.



PROTEIN BIOELECTRONICS: **ADAPTING ENZYMES** FOR **BIOSENSING**

Life depends on a host of almost inexplicably well-organized and balanced enzyme-catalysed processes and the very specific electron transfer reactions underlying them. We aim to control biological electron transfer in enzymes in order to develop artificial bioelectronic systems for medical sensors, dynamic drug analysis and sustainable energy sources.



Assoc. Professor Elena Ferapontova and Post. doc. Maciej Sosna.

Thousands of enzymes provide the reliable function of the bioelectronic system of our body that regulates life-sustaining processes such as respiration, cell maintenance, metabolism, and transmission of signals from the outer world through the nervous system.

All these enzymatic reactions depend on electron transfer, and many scientific efforts aim to elucidate the various ways life uses to control the direction and efficiency of electron transfer reactions. An important goal is to finally develop artificial bioelectronic systems capable of simulating natural electron transfer and operating successfully in vitro. Such systems could be artificial neuronal networks addressing the most complicated issue of information transmission in living organisms, or bioelectronic tongues and noses. Other possible applications are biosensors to be utilised inside the human body, bio-inspired energy harvesting, and development of clean and sustainable power sources capable of extracting energy from ambient raw materials such as oxygen and glucose.

Bio-mimicking enzymes

In my group, we study electron transfer reactions proceeding in enzymes and other proteins involved in the defence systems of living organisms against oxidative, nitrosative or chemical stress. This research is supported by the Danish Council for Independent Research, and we are trying to control biological electron transfers by electrochemical means in order to achieve electron transfer efficiencies comparable or superior to those of biological reactions. An important goal is to mimic bio-catalytic systems for exploitation in blood gas sensors, tumour metabolism sensors, or dynamic laboratory systems for drug analysis.

To achieve efficient bio-mimicking electrochemical function of human defence enzymes, we perform experiments in which we establish electronic communication between electrodes and the redox active centres of the proteins. This can be achieved at the nanoscale by using precisely defined chemical linkers between the electrodes and the protein surface or by introducing artificial conductive relays such as carbon nanotubes or gold nanoparticles into the protein structure. As the enzymes self-assemble on the electrodes, we conserve them in artificial membranes mimicking their natural environment. Such electronically wired enzymes can be fixated in various ways enabling us to study different electron transfer lengths in strictly defined orientations.

Exceeding biological transfer rates

Electronic wiring of enzymes and other proteins has shown impressive results with electron transfer rates several times exceeding those observed under physiological conditions. This allows us to tune the electron transfer and hence the catalytic properties of our bio-electrocatalysts and to integrate them within man-made bioelectrical circuits. Such artificial systems are promising for a wide range of nanobiotechnological applications, e.g. in pathway nanomedicine and pharmacology, bioelectronics, biosensors and biofuel cells.

Electron transfer at work in the body

Respiration

In respiration electrons are generated during the oxidation of carbohydrates and then passed through protein complexes embedded in the inner membrane of the mitochondria, the power plants of the cells. These proteins constitute the transport chain that delivers electrons for the reduction of oxygen to water. The energy released in this reaction is conserved by the generation of a proton gradient across the mitochondrial membrane and further utilised for the synthesis of ATP, the basic biological fuel.

Signal transmission

In signal transmission receptors representing complex enzymatic systems in the sensing organs convert sensory signals into electrical signals, which are transported by neurons into the brain and from there to the muscles that respond instantaneously. These highly specific reactions occur via sequential electron transfer steps across the protein-protein interfaces or internally between different domains of complex enzymes.

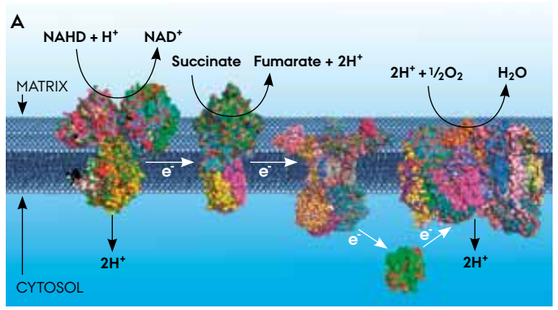
Learning from defence proteins

Haemoglobins against oxidative and nitrosative stress

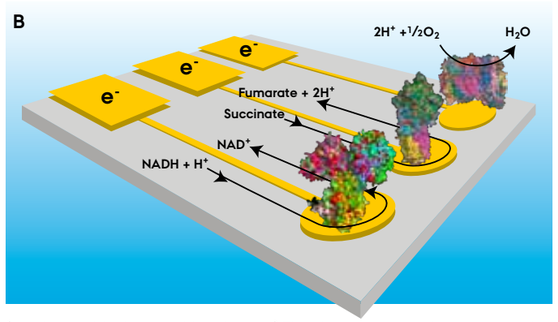
Haemoglobins from plants and bacteria do not only possess a surprisingly high affinity for oxygen. They also have very special ligand-recognition and binding properties in reactions with carbon monoxide, hydrogen sulphide, nitric oxide, cyanide, and reactive oxygen species. These properties of haemoglobins allow us to study biological mechanisms of protection against nitrosative stress and to develop highly sensitive redox biosensors to be applied in vivo for the analysis of diatomic gases and reactive oxygen species involved in carcinogenesis and neurodegenerative diseases.

Cytochromes P450s for metabolism and detoxification

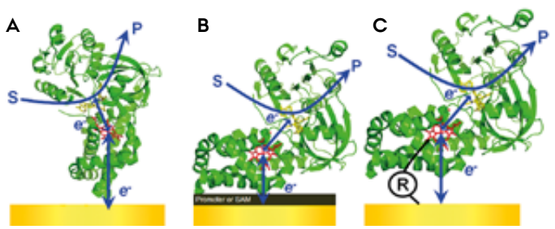
Another key focus of our research is a family of membrane proteins called cytochromes P450s, which are essential for the breakdown of drugs, toxins and other exogenous substances in the liver. This important physiological property makes it possible to utilise these enzymes in directed pharmaceuticals synthesis and for the development of drug screening sensors.



A) The cellular membrane with respiratory chain proteins embedded in it. In the respiratory process, localised in the inner cell membranes, NADH is produced during oxidation of carbohydrates. The electrons generated are passed through the protein complexes, which together constitute the electron transport chain, and are finally used for the reduction of O_2 to water. As a whole, the mitochondrial electron transport chain is composed of four complexes: NADH is oxidised by Complex I (NADH-ubiquinone oxidoreductase) and Complex II



(succinate: ubiquinone oxidoreductase) The electrons are further transferred via a quinone pool to heme-containing Complex III (ubiquinone-cytochrome c reductase or bc1 complex), which catalyses the reduction of water-soluble, heme-containing protein cytochrome c.
Finally Complex IV (cytochrome c oxidase) couples the oxidation of cytochrome c to the catalysis of O_2 reduction to water (B) Schematic of the microelectronic multiarray chip with enzymes assembled at electrodes.



Possible modes of electronic wiring of a complex E.coli flavohaemoglobin to electrodes (A) in arbitrary orientation achieved via adsorption, or (B) in orientated covalent attachment to promoter or self-assembled monolayers, and (C) by cofactor wiring through the single-walled carbon nanotube, a gold nanoparticle, or an organic conductive relay followed by further reconstitution of the protein onto the cofactor wired to the electrode. S is the substrate and P is the product of the enzymatic reaction.

BY MORTEN BJERRIING,
BRIAN STOUGAARD VAD AND
NIELS CHR. NIELSEN

REVEALING **THE SECRETS** OF **INSOLUBLE PROTEINS**

They amount to more than half of all human proteins. They perform essential tasks in our brains and bodies. And yet, the structures of insoluble proteins are virtually unknown, which limits our understanding of how they work. At the inSPIN research centre we take up the challenge of extracting information from insoluble proteins in order to elucidate their decisive roles in health and disease.

Proteins are the machinery of life. Therefore, one of the great challenges in biological science and for nano-bio-medical research in particular is to improve our understanding of the roles and functions of proteins and peptides in mammalian species. To do so, we must reveal the relationship between the structure of individual proteins and their function in the organism.

The workings of soluble proteins can be explored through structural and functional studies, but for insoluble proteins very limited structural information is available. This is unfortunate, because a host of physiologically important proteins are insoluble. An example is the proteins situated in cell membranes. Most biological processes rely on membrane proteins and they are targeted by the majority of current drugs. Another type of insoluble proteins of vital importance to our health is fibrillating proteins, which are prone to misfold into fibres. These proteins are often related to severe neurodegenerative diseases. Furthermore, insoluble proteins form the extracellular matrix between cells and they may be involved in ageing and the distribution of cancer metastases.

The lack of information on insoluble proteins is in striking contrast to the high commercial interest in their secrets. Drugs that interact with these elusive proteins generate a large fraction of the financial turnover in the pharmaceutical industry.

A mutated protein that impairs vision

One project within inSPIN addresses the eye disease corneal dystrophy, which results in massive protein clots deposited in the cornea. The disease can be linked to a number of different mutations of a single protein called Transforming Growth Factor β Induced protein (TGFBIp). Fibrils of the mutated protein aggregate in clots that give the cornea an opaque look and severely impair the vision of the inflicted. So far, the only treatment is corneal transplant.

To improve the condition of the patients and to understand the mechanisms underlying protein fibrillation, we investigate how each mutation steers the protein away from its natural non-harmful role and onto the dark path of misfolding and disease.

Towards the insoluble protein toolkit

Center for Insoluble Protein Structures, inSPIN, is a collaboration of five iNANO research groups including 70 researchers and students at Aarhus University. Our vision is to extract information from insoluble proteins and to establish an interdisciplinary 'insoluble protein toolkit'. These are the tools of the trade:

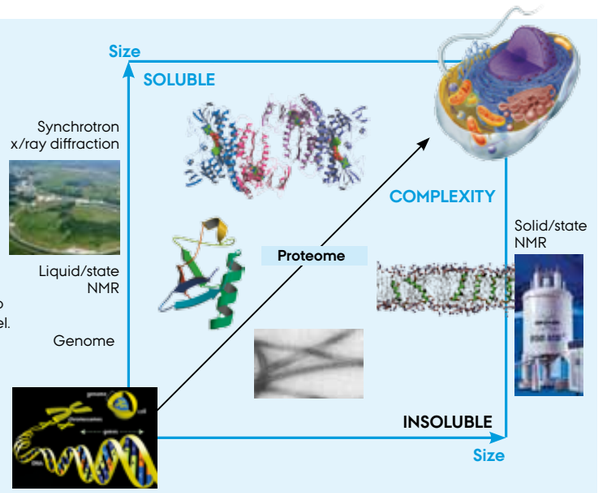
NMR spectroscopy
An analytical technique utilising the behaviour of atomic nuclei in strong magnetic fields to identify structural details of complex proteins.

Protein biophysics
A general approach that applies a variety of spectroscopic techniques to generate data, which can be analysed in a quantitative manner to develop models and mechanisms for conformational changes at the molecular level.

Proteome analysis
A proteome is all the proteins in a tissue, organ, or organism. Proteome analyses are large scale studies aiming to develop a structure-activity-function algorithm of the proteins.

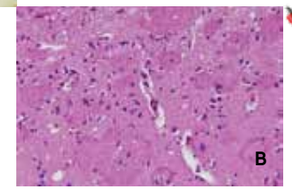
Synthetic organic chemistry
This is the art of building small molecules including the development of new synthetic methodology.

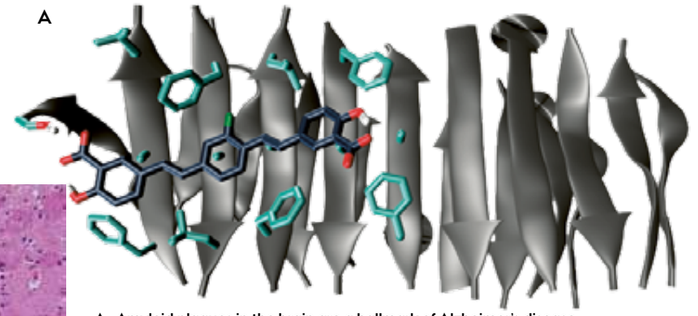
Bio-modelling
Computational methods for obtaining a better understanding of the biochemical processes.



Today, the structure and function of thousands of water soluble proteins is well known, but little information is available on insoluble proteins even though they are of utmost importance to the pharmaceutical industry.

The eye disease corneal dystrophy impairs vision due to a mutated fibrillating protein that aggregates and forms clots in the cornea.





A Amyloid plaques in the brain are a hallmark of Alzheimer's disease.
B The plaques are formed by fibrils of the -amyloid peptide. Hopefully, small molecules that bind to the peptides during fibrillation may be able to stop their development.

To get to the heart of the matter, we have isolated the specific protein region responsible for corneal dystrophy and established a library of protein mutations isolated from patients.

Using biophysical techniques, the stability of the correctly folded protein and the mutants has been analysed in order to describe the different folding pathways of disease and non-disease forms. Meanwhile, NMR spectroscopy studies have uncovered the minute structural differences at the atomic level triggering the disease-prone fibrillation.

Our findings show that the clots of TGFBIp mutants can be separated in amorphous and amyloid aggregates. The different mechanisms of aggregation appear to be triggered by small structural changes induced near the mutation sites. Based on this information we are able to identify organic compounds that bind intermediate states during protein folding. Such compounds will be valuable for structural studies and hopefully for future clinical treatments.

Early diagnosis of Alzheimer's disease

A hallmark in the progression of the deadly type of dementia, Alzheimer's disease, is the deposition of plagues of β-amyloid peptide in the brain. So far the disease is diagnosed by the onset of clinical symptoms such as loss of memory and cognitive skills, but at that stage it is believed that the brain has already sustained permanent damage. Thus, the road towards a cure or a medical treatment to improve the condition of the patients begins with an early diagnosis enabling doctors to act before actual symptoms occur.

Our approach for an early-stage diagnosis is amyloid imaging involving tracers that bind to the β-amyloid fibrils. Through the incorporation of fluorine isotopes, either the stable ^{19}F or the radioisotope ^{18}F, these tracer compounds enable the detection of amyloid deposits by magnetic resonance imaging (MRI) and positron emission tomography (PET). A range of potential tracer compounds with high affinity for β-amyloid deposits have been developed, and they are currently undergoing tests to setup an experimental protocol for animal and clinical models to evaluate the effect of dementia drug candidates.

inSPIN group leaders in front row:
Frans Mulder, Thomas Vosegaard, Birgit Schiøtt, Niels Chr. Nielsen, Troels Skrydstrup, Jan J. Enghild and Daniel Otzen.

UNIQUE RESEARCH **COLLABORATION** WITH **CHINA**

The joint center 'Sino-Danish Center for Self-assembly and Function of Molecular Nanostructures on Surfaces' (hereafter referred to as Sino-Danish Center) focusses on the study of fundamental aspects of the self-assembly of molecular building blocks and an iterative refinement of molecular designs to build molecular nanostructures with specific function.

2011 was an excellent year for the joint center. Not only have we made great progress toward achieving our original scope to build a strong research center between two countries with quite different cultural backgrounds, but we were granted another DKK 10 million to extend the center for a second three-year period from 2012 to 2015.

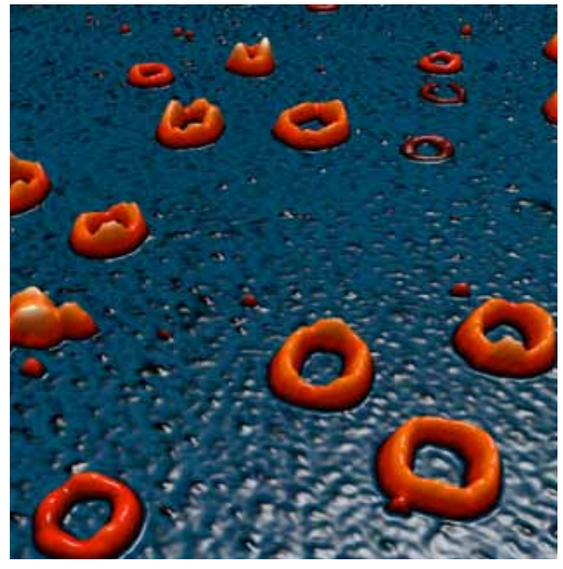
The self-assembly of molecules and molecular recognition underlies all processes of living organisms and the self-assembly and function of molecular nanostructures is therefore a central theme within the emerging field of nanoscience and nanotechnology. Using powerful nanotools, including Scanning Tunneling Microscopy, Atomic Force Microscopy, and electron microscopy, we have identified the assembly structures of biomolecules in real space, thus providing a general methodology to study the binding mechanism from the atomic scale, nanoscale, microscale to the macroscale. The exploration of molecular interactions at the molecular level is important to the fundamental understanding of how the immensely complex processes of Nature's molecular machinery operate. It also provides insight into molecular mechanisms in chemical processes and enables us to design artificial self-assembled structures with desired properties and functions.

The joint Sino-Danish center is organized into three main focus areas; i) Fundamentals of molecular self-assembly on surfaces, ii) Design and on-surface synthesis of self-assembled nanostructures, and iii) Function of molecular nanostructures. The center thus bridges the gap from basic, fundamental studies of molecular self-assembly, through the design and synthesis of desired nanostructures and finally to exploitation of the functional properties of self-assembled molecular nanostructures in a number of application areas. Since 2009, the Sino-Danish center has financed 12 professors, 10 postdocs, 16 PhD students, 2 Master's students to exchange and perform research at partner departments. It also performs as an indispensable bridge for Danish and Chinese researchers to exchange their opinions on scientific topics. The researchers from the program meet annually to discuss their joint projects and develop new projects to address the challenges in the field. The researchers also visit their partners' labs to improve the project results and communicate with each other. Recently, iNANO and NCNST started their first joint PhD program with two supervisors from the Sino-Danish Center. The PhD students will spend half of their time in Denmark and half of their time in China.

After more than two years of hard work, the Sino-Danish center has demonstrated important results on protein polymerization, functional molecular surface self-assembly and functional material fabrication. Until the end of 2011, the center has published more than 10 joint papers in peer-reviewed journals including Journal of American Chemistry Society. More importantly, three of these works have been chosen as cover stories. The scientists from both sides dedicate their knowledge and experience to successfully assemble molecules into 2D lamella structures and further build structures such as nanofibrils, nanotubes and nanospheres. Some of the possible applications have been further explored in the center including the role of amyloid fibrils in materials mechanics, peptide fiber scaffolds in cell culture and tissue engineering, and peptide nanotubes and amyloid fibrils in nanoelectronics.

The challenge ahead is to construct other functional nanomaterials from self-assembling molecules with unique sizes and specific shapes. It would be a step forward to integrate other molecules, such as polymers, inorganic nanoparticles and organic molecules with specific chemical groups, into the polypeptide system and functionalize the assemblies to a greater extent. These functional polypeptide assemblies could be used as the components of sensors. Self-assembling polypeptides may have a significant impact on the medical field. In the coming three years, the Sino-Danish Center will continue to act as a great platform for talented researchers from both Denmark and China to discuss and explore valuable scientific questions.

High-resolution atomic force microscope image of annular insulin structures on a negatively charged surface after 40 h of incubation under liquid conditions.



A case study on the direct visualization of protein self-assembly on surfaces

Cell surfaces allow accumulation or adsorption of proteins. The electrostatic and hydrophobic properties of cell membrane will strongly influence the interaction with proteins. Such interaction will change the folding/unfolding equilibrium of proteins, which will result in new pathways for protein assembly. The mechanism of protein assembly on surfaces is poorly understood and it can be particularly useful to investigate and directly visualize the assembly process to gain insight into how biological systems work.

With this perspective, iNANO teams lead by Professor Flemming Besenbacher and by Professor Yanmei Li from Tsinghua University investigated peptide assembly on surfaces under biological conditions.

A remarkable degree of structural polymorphism during the protein assembly process was uncovered, leading to significant differences in both stability and conformation. In particular, Atomic Force Microscopy was utilized to observe morphological changes of the disease-related proteins deposited on surfaces; the structure on the surface clearly shows the difference from that occurring in bulk solution phase because of restrictions imposed by the physicochemical properties of the surface.

In addition, the co-assembly of two co-secreted human proteins was visualized. By tuning the ratio of two proteins, the nanostructure morphology changes from fibrils to oligomers to annular [next].

The studies with joint effort provide complementary information about the assembly structures and establish the basis for a better understanding of physiological processes and the function of protein assembly in biological systems.

1 Soft Matter, 2012, 8, 1616-1622
2 Chem. Commun., 2012, 48, 191-193
3 ACS Nano, 2011, 5 (4), pp 2770–2778
4 Chem. Eur. J. 2012, 18, 2493 – 2497
5 Phys. Chem. Chem. Phys., 2011, 13, 17435-17444

iNANO AND INDUSTRY

2011 was another exciting year at iNANO. While the formal change of director happened at the beginning of 2012, the actual transition period started well before. The founding director of iNANO, Professor Flemming Besenbacher, stepped down and Professor Niels Chr. Nielsen took over.

Message from the Chairman
Flemming can be praised for his unparalleled foresight when in 2001 he sensed the rise of nanoscience as a most promising and fruitful scientific field of the future, straddling traditional disciplines such as physics, chemistry, biology, and medicine. It is in the interface of these disciplines that a wealth of new opportunities for groundbreaking research emerges, as iNANO has so beautifully demonstrated since then.

The creation and nurturing of a national and international network of top scientists and policy makers is another specific competence of Flemming's. It is with good reason that he was named the most influential figure in Danish research, a position that has been consolidated through his many new commitments, now also reaching into Danish and international business. I know that iNANO remains very close to his heart and that he will provide advice and support also in the future.

I would like to take this opportunity to welcome Niels Chr. as the new director. He was asked to take over due to his excellent leadership skills and deep insight into the Danish and local institutions that affect the iNANO operation. I wish him the very best of luck in his new position and I am very much looking forward to working with him.

The new leadership takes over at a time of significant transformations where many established structures are eliminated and new ones built up. During 2011, Aarhus University (AU) rolled out a major reorganization of the entire university. As a natural consequence of the merger with several other institutions, the faculty and department structure was simplified and its management professionalized, both in terms of structure and people. This new situation has brought with it an increased focus on departmental strategies and demarcation lines. This may create a more difficult situation for iNANO, which operates at the borderlines between disciplines and departments. Our challenge is to continue to demonstrate and communicate that iNANO is a unique organization, which brings with it unique opportunities that benefit everyone involved; the success of iNANO is the success of the departments.

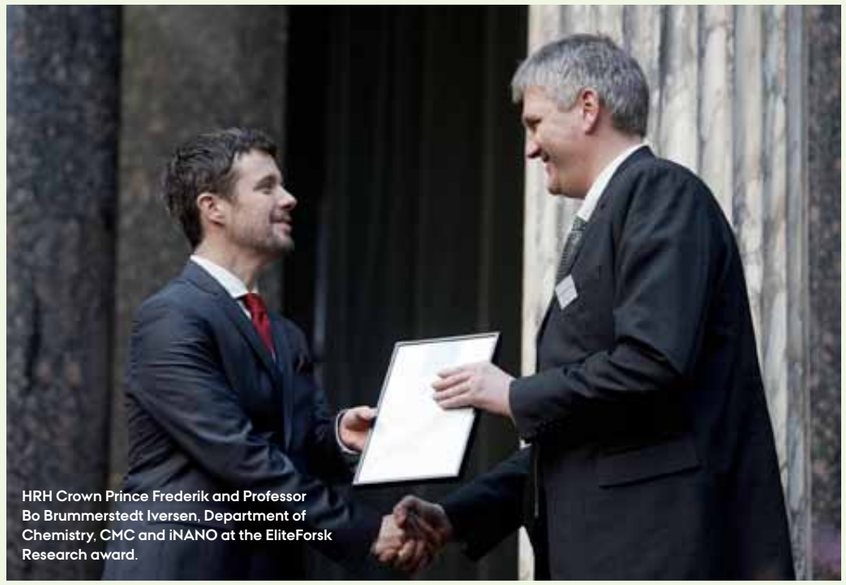
Looking forward, 2012 will see the inauguration of the new iNANO house. Its 10,000 m^2 will soon start buzzing with ideas and dedicated researchers. iNANO will transform from a virtual into a physical entity, bringing with it even closer interactions and new collaboration opportunities with university institutions and industry.

The future indeed looks bright for iNANO.

Bjerne Clausen
Chairman of the iNANO Board
Chief Executive Officer
Haldor Topsoe A/S

HIGHLIGHTS 2011

Every year iNANO scientists receive numerous awards and honourable distinctions for their scientific achievements. Indeed, 2011 was no exception from this trend, and here is a snapshot of brilliant moments in 2011. Other outstanding recognitions are also presented on pages 22-23, 24-25 and page 38.



HRH Crown Prince Frederik and Professor Bo Brummerstedt Iversen, Department of Chemistry, CMC and iNANO at the EliteForsk Research award.

Professor Bo Brummerstedt Iversen receives the EliteForsk award
In January 2011 one of five annual EliteForsk (elite researcher) awards was given to Professor Bo Brummerstedt Iversen, iNANO researcher and director of the affiliated Center for Materials Crystallography for his significant contribution to the research and understanding of thermoelectrical materials. The prize consists of DKK 1 million for research activities and DKK 0,2 million as a personal award.

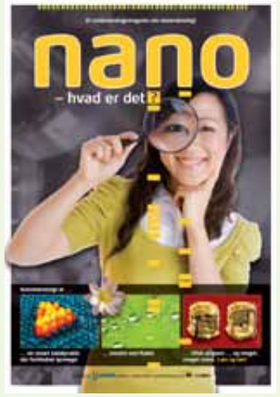
PHOTO: REPRINTED WITH PERMISSION FROM THE DANISH AGENCY FOR SCIENCE, TECHNOLOGY AND INNOVATION. PHOTO BY TARIQ MIKKEL KHAN.

iNANO PhD students win poster awards and best oral presentations
At the Summer School "Energy and Materials from the Sun" PhD student Ren Su won the poster prize for the poster titled: "The impact of anatase: rutile ratio on the photo-reactivity of TiO2". The Summer School took place at Rolduc Abbey, Kerkrade, The Netherlands, from June 20 to 23, 2011. The topics of the Summer School included renewable sources, photochemistry, photovoltaics, synthetic fuels, biomass utilization, clean combustion technology, and materials for energy applications.

Likewise, PhD student Hanna Leemreize received a prize for her poster entitled: "Architecture and Crystalline Phases of the Mineralized Holdfast System of the Saddle Oyster" at the five-week course HERCULES (Higher European Research Course for Users of Large Experimental Systems), which is organized by Université Joseph Fourier (UJF) and the Institut National Polytechnique de Grenoble (INPG) and held in Grenoble. This five-week European course aims to train young scientists in the use of large instruments by providing a general overview of the techniques and scientific possibilities associated with neutron and synchrotron radiation to investigate condensed matter or biomedical topics.

At the "The 32nd Annual Danish NMR Meeting" in January two prizes were given to iNANO PhD students. Søren Sørensen

(iNANO and Instrument Centre for Solid-State NMR Spectroscopy) received the prize for the best oral presentation by his talk entitled "Structural Investigations of catalytic zeolite ZSM-5 samples by solid-state NMR spectroscopy" and Mads Sloth Winding (iNANO, inSPIN and CFIN) was awarded the best poster presentation for his poster entitled "Monotonic and global convergent optimization od 2DRF pulses incorporating relaxation".



iNANO publishes teaching book for primary schools on nanotechnology
The small booklet named, NANO – what is that?, is the result of a joint project between iNANO and the TURBINE Publisher funded by the Danish Council for Strategic Research and TIPSMIDLER.

The booklet is intended to introduce the nanotechnology concept to primary school children, teach them about current nanoscience research and how nanotechnology may help future developments in our society. In February 2011 the booklet was distributed to all Danish primary schools in more than 60,000 copies.

Flemming Besenbacher elected Fellow of the American Physical Society
In the beginning of 2011 Professor Flemming Besenbacher was elected Fellow of the American Physical Society (www.aps.org) "for contributions to the understanding of atomic scale processes on solid surfaces, leading to breakthroughs in catalysis and nanotechnology." His nomination by colleagues in the APS Condensed Matter Physics division went through the APS Council and is thus a distinct honour signifying recognition by his professional peers.

Jan Skov Pedersen world-class chemistry researcher
Professor Jan Skov Pedersen, iNANO and Department of Chemistry, Aarhus University, was awarded the Elastyren Prize by the Danish Academy of Technical Sciences (ATV).

He was awarded the prize for his extensive internationally recognised contribution to research in polymer chemistry. Professor Pedersen's research covers developing instrumental techniques for characterisation, essential basic research in polymers, and research of direct relevance to medicine. This includes paving the way for new material applications in drug delivery, i.e. the ability to 'carry medicine into the body'. He has also worked on models for Parkinson's disease and studied the behaviour of proteins. The prize is valued at DKK 100,000 (approximately EUR 13,500).

Strengthened ties to China
Over the last five years iNANO has developed strong research connections to leading universities in China. These scientific ties were further strengthened in 2011 when Professor and Director Flemming Besenbacher was appointed Overseas Director and Honorary Professor at Tongji and Jiangsu Universities, respectively.

Tongji University is the highest ranking university in the Shanghai region and has been inspired by the iNANO concept to open the cross-disciplinary "Tongji-Aarhus Joint Center for Nanostructures and Functional Nanomaterials". Flemming Besenbacher was appointed Overseas Director of the center, where he will act as an advisor on the centre's scientific and strategic activities. Furthermore, at Jiangsu University in Zhenjiang Professor Besenbacher was appointed Honorary Professor at the Institute of Advanced Materials.

Aarhus University already has an exchange agreement with Jiangsu University, but by appointing Professpr Besenbacher Honorary Professor, the intention is to strengthen collaboration on research and education within the area of materials science.

Also Harbin Institute of Technology in Northeastern China has been inspired by the iNANO model, leading in 2011 to the establishment of Harbin-Aarhus International Center of Surfaces and Interfaces (HAISI) and the appointment of Professor Besenbacher as Honorary Doctor at HIT and Chairman of the international advisory board.

Philip Hofmann awarded the Gaede Prize 2011
Professor Philip Hofmann, iNANO and Department of Physics and Astronomy, was awarded the Gaede Prize by the German Vacuum Society for his pioneering work on the physics of two-dimensional electron systems with a strong spin-orbit interaction. Professor Hofmann's research focuses on materials whose surface properties are entirely different from those of the bulk because of the broken symmetry introduced by the surface. The Gaede Prize of the German Vacuum Society (DVG), donated by Dr. Manfred Dark and funded by the Oerlikon Leybold Vacuum GmbH (Cologne), has been awarded annually since 1986. The award is given work in the fields of basic research and application in the areas served by the DVG. The prize is valued at EUR 10,000.

MAJOR AWARDS OF 2011

Professor George Whitesides, Harvard University, receives honorary doctorate at Aarhus University

Aarhus University's highest honor, the honorary doctorate, was conferred to Professor George Whitesides on September 9, 2011, on the day of the University's annual celebration.

Professor George M. Whitesides is the world's most highly cited chemist, and he has made invaluable contributions to science research throughout his long academic career. The American professor has left his imprint on physical and organic chemistry, materials science, surface science, biophysics and complex systems, not to mention microtechnology and nanotechnology. His more than one thousand scientific publications include no fewer than fifty articles in the leading journals Science and Nature. Professor Whitesides' list of credentials also includes the American National Medal of Science and the Kyoto Prize for Advanced Technology. He is an honorary fellow of a considerable number of scholarly societies, and he has acted as an adviser to the American government.

During his visit, Professor Whitesides gave two talks at iNANO. The first talk was on a scientific subject ("Charge Transport by Tunneling across Self-Assembled Monolayers. Asking Hard Questions about Science") and the second lecture was a more general one on "Some Opportunities in Energy-Related Research".

The latter can be found online at: http://inano.au.dk/news-events/news/artikel/george-whitesides-inano-lecture-available-online/

Professor Flemming Besenbacher receives Aarhus University's highest research award

On 27 May 2011 Professor Flemming Besenbacher was awarded the Rigmor and Carl Holst-Knudsen Award for Scientific Research. Professor Flemming Besenbacher receives the award for his groundbreaking contributions to surface science and the development of the "Aarhus STM" and for his tireless efforts in bringing Danish nanoscience towards the highest international level.

The Rigmor and Carl Holst-Knudsen Award was established on 28 May 1956 on the occasion of Carl Holst-Knudsen's 70th birthday, and it is awarded once a year to researchers who started their career at Aarhus University. In addition to the recognition given to the recipients, each researcher receives DKK 100,000 as a personal award.

10TH iNANO **ANNUAL MEETING** 2012

The 10th iNANO annual meeting took place on 18 January 2012. Again this year, iNANO managed to attract six high-profile speakers from around the world who delivered inspiring talks on nanoscience topics. In addition to the invited lectures, the iNANO PhD students and postdocs presented their research activities at a poster session with an impressive number of poster contributions. The day ended with an evening dinner at the Department of Chemistry.

Optical Materials Science
Roger H. French from Solar-Durability and Lifetime Extension Center, Case Western Reserve University, was the first speaker of the day. Taking single-walled carbon nanotubes as a test material, Professor French brought about insight into the role of van der Waals – London dispersion (vdW-Ld) interactions for nanoscale assembly and the creation of optical and electronic structure of materials.

Nanopore-Confined Matter: Towards Stable Energy Storage and Catalytic Materials
Petra E. de Jongh from Debye Institute for Nanomaterials Science, Utrecht University, gave a talk on the impact on hydrogen sorption properties of nanosized metal hydrides (<10 nm), how to confine them in a nanoporous matrix and how this influences the equilibrium and reversibility of the hydrogen sorption reaction.

Neurodegeneration and interfering with it: An NMR spectroscopic view
Christian Griesinger from the Department for NMR-based Structural Biology, Max-Planck Institute for Biophysical Chemistry, addressed topics on NMR liquid and solid state characterization of the polymorphic forms of α-synuclein, how different mutants make faster aggregates and exhibit higher toxicity and how the aggregation landscape of α-synuclein could be modified by small molecules.

Adhesion and Mechanosensing at Intercellular Junctions
Deborah Leckband from University of Illinois at Urbana-Campaign presented her detailed studies on the mechanism by which cadherin binding signals propagate mechanical information through tissues via intercellular contacts. The studies were performed using micro- and nanomechanical force probes to interrogate both the adhesive properties of cadherin bonds and the mechanism of mechanotransduction at cadherin-based intercellular junctions.

Scanning probe microscopy of molecules on insulating films: From orbital imaging to molecular structure determination
Gerhard Meyer from IBM Research talked about how ultrathin insulating films on metal substrates are unique systems in which the scanning tunneling (STM)/ atomic force microscope (AFM) can be used to study electronic and structural properties of single atoms and molecules. The insulating films on the metal substrates are electronically decoupled from the metallic substrate, which in the case of the STM allows for the direct imaging of the molecular frontier orbitals. In combination with atomic/molecular manipulation this opens up the possibility to study elementary processes related to charge state control, molecular switching and electrical contact formation.

The art of building small; designing dynamic chemical systems
Professor Ben L. Feringa from Center for Systems Chemistry, Stratingh Institute for Chemistry & Zernike Institute for Advanced Materials, University of Groningen, gave a fascinating talk on how he and his colleagues had succeeded in synthesising artificial molecular mimicries of molecular motor systems and switches in which molecular dynamics is coupled to specific functions. The design, synthesis and functioning of rotary and linear molecular motors was presented.

PUBLICATIONS

In 2011 iNANO published 309 peer-reviewed articles. A complete list of both iNANO publications and specialized lectures can be found at our homepage.
Publications 2011: http://inano.au.dk/news-events/specialized-inano-lectures/2011/
Specialized lectures 2011: http://inano.au.dk/news-events/distinguished-inano-lectures/2011/

iNANO LECTURES 2011

January 7, Research Fellow Anpan Han, Harvard University, Cambridge, Massachusetts, USA: Single Molecule Trap

January 14, Lecturer in Physical Chemistry, Tim Albrecht, Imperial College London, London, USA: Charge transport at the nanoscale

January 28, Science Director, Dimitri N. Argyriou, European Spallation Source (ESS) AB, University of Lund, Sweden: Looking into the future of neutron scattering with ESS: Current status and scientific opportunities

February 4, Professor Roman Fasel, Empa, Swiss Federal Laboratories for Materials Science and Technology & Department of Chemistry and Biochemistry, University of Bern, Bern, Switzerland: Bottom-up synthesis of graphene-related materials

February 11, Professor Itamar Willner, Institute of Chemistry, The Hebrew University of Jerusalem, Jerusalem, Israel: Nanotechnology with biomo lecules

February 25, Head of Group, Dr. Colm Durkan, University of Cambridge, Department of Engineering, Cambridge Nanoscience Center, Cambridge, UK: Nanoscale Domain Dynamics and Relaxation in Thin ferroelectric/ferroelastic Films

March 4, Dr. Kislon Voitchovsky, Institute of Materials Sciences, Ecole Ployténique Fédérale de Lausanne (EPFL), Lausanne, Switzerland: Atomic force microscopy at the solid-liquid interface: From biomolecules to complex artificial systems

March 11, Assistant Professor Christian Klinke, Institute of Physical Chemistry, Interdisciplinary Nanoscience Center Hamburg, University of Hamburg, Hamburg, Germany: Tailored nano architectures: Nanotubes, nanoparticles and composites for future electronic devices

March 18, Professor Mike Eaton, ETP Nanomedicine & School of Pharmacy, University of Nottingham, Nottingham, UK: Can Nanomedicine in Europe adapt to the Consequences of Globalisation?

March 25, Professor Fraser Armstrong, Inorganic Chemistry Laboratory, Oxford University, Oxford, UK: Efficient Electrocatalysts for Future Energy Technology: The Importance of Understanding How Enzymes Work so Well

April 1, Professor Marc Baldus, Bijvoet Center for Biomolecular Research, Utrecht University, Utrecht, The Netherlands: An NMR view of biomolecular architecture & function

April 1, Professor James H. Naismith, St. Andrews University, Scotland, UK: Conformation States in lipid bilayers

April 8, Dr., PhD, Director Chanmin Su, Technology, AFM BU, Bruker Nano, Inc., Santa Barbara, USA: Identifying Molecules by Touching - Quantitative Nanomechanical Characterization Using Atomic Force Microscopy

April 15, Professor Andrew Ewing, Analytical Chemistry, Department of Chemistry, University of Göteborg, Göteborg, Sweden: Electrochemical measurements at single cells and vesicles

May 6, Professor Justin Gooding, School of Chemistry, The University of New South Wales, Sydney, Australia: Biosensors: The Benefits of Nanotechnology

May 13, Professor Dimitrios Stamou, Bionanotechnology Laboratory, University of Copenhagen, Copenhagen, Denmark: Lipid Membrane Nanotechnology for Synthetic Biology

May 24, Nobel Prize Winner & Senior Research Associate Jan Hall, JILA, University of Colorado, Boulder, Colorado, USA: Lasers and fundamental physic

May 27, Professor Werner A. Hofer, Stephenson Institute for Renewable Energy, Department of Chemistry/Physics, University of Liverpool, Liverpool, UK: Dynamics at the atomic scale: Vibrations, diffusion, and reactions of molecules

June 10, Professor S.M. Moghimi, Centre for Phamaceutical Nanotechnology and Nanotoxicology, University of Copenhagen, Copenhagen, Denmark: Nanomaterial Properties in Complement Activation and Related Adverse Reactions: Towards Engineering of Immunologically Safe Nanomedicines

June 17, Vice-Dean for Research & Chairman of the European Energy Alliance Henrik Bindslev, Faculty of Science and Technology, Aarhus University, Aarhus, Denmark: Flexibility in the future energy system

June 24, Professor Mikael Käll, Binanohotonics, Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden: Nanoplasmonics – antennas, sensors and the optical force

July 1, Dr. Maximillian Fichtner, Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany: Kinetic and Thermodynamic Properties of Nanoconfined Materials for Energy Storage

August 12, Associate Professor Bryan D. Huey, Institute of Material Sciences, University of Connecticut, Connecticut, USA: Atomic Force Microscopy and High Speed Imaging

August 19, Dr. Richard Douthwaite, Department of Chemistry, University of York, Heslington, York, UK: Synthesis and development of materials for energy research

August 26, Professor Wilson Ho, Department of Physics and Astronomy & Department of Chemistry, University of California, Irvine, California, USA: Probing single molecules by atomic scale inelastic tunneling

September 2, Professor Tim Liedl, Department für Physik - Lehrstuhl Rädler, Ludwig-Maximilians-Universität, Münich, Germany: Creating optically active fluids with DNA origami

September 8, Professor George M. Whitesides, Whitesides Research Group, Department of Chemistry and Chemical Biology, Harvard University, Cambridge, USA: Charge Transport by Tunneling across Self-Assembled Monolayers. Asking Hard Questions about Science

September 9, Professor George M. Whitesides, Whitesides Research Group, Department of Chemistry and Chemical Biology, Harvard University, Cambridge, USA: Some Opportunities in Energy-Related Research

September 16, Professor Rachel K. O'Reilly, Department of Chemistry, University of Warwick, Coventry, UK: Using DNA as a tool for controlled syntheses and assembly

September 23, Director and Professor Rafal E. Dunin-Borkowski, Institute for Solid State Research, Forschungszentrum Jülich, Jülich, Germany: Quantitative and in situ TEM of functional properties and dynamic processes in nanoscale materials and devices

September 30, Postdoctoral Research Associate Megan Yi-Ping Ho, Department of Biomedical Engineering, Duke University, Durham, NC, USA: Convergence of Nanophotonics and Microfluidics for Nanomedicine in Theranostics

October 14, Professor, Dr. Stefan U. Egelhaaf, Department of Physics of Soft Matter, International Helmholtz Research School on Biophysics and Soft Matter, Heinrich-Heine-Universität, Düsseldorf, Germany: Flow into and through nanoporous matrices - neutron imaging experiments

October 21, Professor Dr. Hellmut Eckert, Institut für Physikalische Chemie, Westfâhlische Wilhelms-Universität, Münster, Germany: New Magnetic Resonance Approaches Towards the Structural Characterization of Luminescent Ceramic Materials

October 28, Associate Professor Marianne Glasius, Department of Chemistry, Aarhus University, Aarhus, Denmark: Where do organic aerosols in the atmosphere come from?

November 4, Professor Moustapha Kassem, The Medical Biotechnology Center, University of South Denmark, Odense, Denmark: Human Mesenchymal (Skeletal) Stem cells: Targets for skeletal tissue regeneration

November 11, Scientific Group Leader & Director Albert Polman, FOM Institute AMOLF, Institute of the Foundation for Fundamental Research on Matter (FOM), Amsterdam, The Netherlands: Light trapping in photovoltaic nanomaterials

November 18, Professor Dr. Michael Froeba, Institute for Inorganic and Applied Chemistry, Department of Chemistry, University of Hamburg, Hamburg, Germany: Metal-Organic Frameworks for the Storage and Separation of Gases

November 25, Professor & Dr.rer.nat. Günter Mayer, Life and Medical Science Institute, (LIMES), University of Bonn, Bonn, Germany: Plug and play with aptamers

December 2, Associate Professor Kresten Lindorff-Larsen, Department of Biology, Section for Biomolecular Sciences, University of Copenhagen, Copenhagen, Denmark: Elucidating the Structural Dynamics of Proteins by Simulations

December 9, Professor, Dr. Bert Poolman, Groningen Biomolecular Sciences and Biotechnology Institute and Zernike Institute for Advanced Materials, University of Groningen, Groningen, The Netherlands: Traffic in crowded environments and osmosensing mechanism of an ABC transporter

December 16, Professor Joshua Brickman, The Danish Stem Cell Center, University of Copenhagen, Copenhagen, Denmark: Cellular indecision – how embryonic stem cells make lineage choices

PHD THESES PUBLISHED 2011

Rangnekar, Functional DNA Nanoarchitectures, 2011

Anders Kyrme Tuxen, Atomic-scale investigations of MoS2-based hydrotreating catalysts

Antonello de Calcutta, Global protein Folding State mapping by NMR Spectroscopy: Application to Membrane Protein

Arcot R. Lokanathan, Strategies for creating antifouling surfaces using selfassembled poly(ethylene glycol) thiol molecules

Bjarke Jørgensen, Hydrogen interaction with carbonaceous materials

Claudia Ulrich Hjørringgaard, Solid-Phase Peptide Synthesis and Scaffolding of Alamethicin and Analogs

Dorthe Bomholdt Ravnsbæk, Synthesis, structure and properties of novel metal borohydrides

Estephania Lira Salazar, The role of surface and subsurface defects in the adsorption of oxygen and the adhesion of metals on TiO2(110)

Francesca Macchi, Shaken not stirred-mechanical perturbaion and protein aggregation

Frank Horsbøl Iversen, RNA interference in drug delivery

Grette Vestergaard Jensen, Scattering Studies of Micelles in Solution

Hao Yin, Development in Zn4Sb3- based Thermoelectric Materials

Huabing Wang, Protein-surfactant interactions

Isabel Nawroth, Intervention of radiation-induced skin fibrosis by RNA interference

Jane Savskov Petersen, Extracellular superoxide dismutase

Johan Frederik Kraft, Computational Studies of Membrane Mimics and Peptides

Jonas Günsel, Absorption properties of beta-Sn nanocrystals in SiO2

Karina Matthiesen, Regulation of Cyclic AMP by Phosphodiesterases

Kasper Jahn, Advances in Structural and Functional Properties of DNA Nanotechnology

Lene M. Arnbjerg, Synthesis and study of complex metal hydrides

Lindsay Richard Merte, Ultrathin iron oxides on Pt(111

Lisbeth Moreau Andersen, Factor VIIA-stimulating Monoclonal antibodies and RNA atamers

Lone Tang, Biofilm formation on abiotic surfaces

Lotte D'Andrea, Markert Cellular Responses to Microtopographical Cues

Mads Møgelmose Kjeldsen, Tin Nanoparticles and Silicon-Based Materials

Mads Ry Vogel Jørgensen, Charge Densities of Magnetic Coordination Polymers

Manja Annette Behrens, Scattering Studies of Polymreic Micelles and Biological Macromolecules

Manjunath Puttaswamy, Growth Mechanisms of Aluminum Oxide Thin Films Deposited on Different Polymers Using Atomic Layer Deposition

Morten Karstoft Rasmussen, Polar Metal Oxide Surfaces of MgAl2O4 and ZnO Studied with Non-Contact Atomic Force Microscopy

Niels Vinter Voigt, Aplication of DNA as a Smart Material

Peipei Huo, Interactions with Ethanol and Oxygen with rutile Ti02(110)

Ramesh Subramani, Self-assembly of DNA Nanostructures Studied by Scanning Probe Microscopy

Reza Mohammadzadegan, Constructing and functionalizing DNA nanostrudtures

Sune Bejerholm Villadsen, Roles and regulation of microRNAs in cancer

Søren Sørensen, Structural Studies of ZSM-5 Zeolites and Related Heterogeneous Catalysts by Solid-State NMR Spectroscopy

Thai Thuan Tran, Fluoride Mineralization of Portland cement

Thomas Tørring, Controlling Function and Structure with DNA

Tine Fly Sevelsted , Solid-state 13C, 27Al and 29Si MAS NMR investigations of Portland Limestone cements

Toke Peter Krogager Hansen, Effects of elaidic acid in a HepG2-SF liver cell model: Identification of protein biomarkers and cellular responses in relation to lipid metabolism and cardiovascular disease

Vijay Shankar, Novocidin interactions with phospholipid membranes

PATENTS 2011

Morten Foss, **Kam Leong**, **Andrew Adler**, Improvement of gene transfection by topographical features, 61/490,410

Bo Brummerstedt Iversen, **Mogens Christensen**, **Ye Sun**, A thermoelectric zinc antimonide thin film, PA 2011 70484

Bo Brummerstedt Iversen, **Mogens Christensen**, **Ye Sun**, A thermoelectric zinc antimonide thin film, PA 2011 70483

Bo Brummerstedt Iversen, **Mogens Christensen**, **Hao Yin**, Method for Producing a Thermoelectric Solid Element, PA 2011 70394

T. Skrydstrup, **A. T. Lindhardt**, **T. Gøgsig**, **R. Taaning**, **H. Audrain**, **D. Bender**. System providing controlled delivery of gaseous 11CO for carbonylation reactions in the preparation of radiopharmaceuticals for PET imaging, PA 2011 70516

T. Skrydstrup, **A. T. Lindhardt**, **T. Gøgsig**, **R. Taaning**. Process for the synthesis of 1,3-dicarbonyl compounds using carbon monoxide, PA 2011 70515

T. Skrydstrup, **A. T. Lindhardt**, **P. Hermange**, **R. Taaning**, **S. D. Friis**, System providing controlled delivery of gaseous CO for carbonylation reactions, PCT/DK2011/050480

iNANO administration. Back row: Rebeca Thostrup, Leif Schauser, Kaj Jensen and Peter Thostrup. Front row: Annette Wandahl, Sys Zoffman Glud and Trine Møller Hansen.

APPOINTMENTS OF STAFF ASSOCIATED WITH iNANO in 2011

Thomas Vosegaard was appointed Professor with Special responsibilities at Aarhus School of Engineering

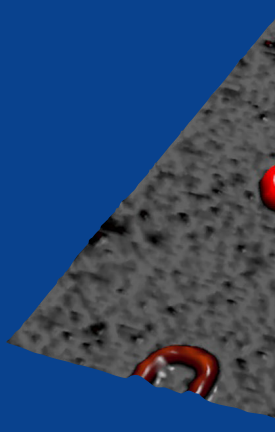
Frans Mulder was employed as Associate Professor at Department of Chemistry

Stefan Wendt was appointed Senior Researcher at iNANO

George Whitesides was appointed Honorary Professor at iNANO and AU

SENIOR STAFF

Andreasen, Peter
Baatrup, Erik
Balling, Peter
Besenbacher, Flemming
Birkedal, Henrik
Birkedal, Victoria
Bøttiger, Jørgen
Christensen, Mogens
Daasbjerg, Kim
Duch, Mogens
Dong, Mingdong
Enghild, Jan Johannes
Ferapontova, Elena
Foss, Morten
Gao, Shan
Glasius, Marianne
Gothelf, Kurt Vesterager
Hammer, Bjørk
Hofmann, Philip
Hornekær, Liv
Howard, Ken
Iversen, Bo Brummerstedt
Jakobsen, Hans Jørgen
Jensen, Jan Egebjerg
Jensen, Torben René
Keiding, Søren
Kjems, Jørgen
Knudsen, Birgitta
Knudsen, Charlotte Rohde
Larsen, Arne Nylandsted
Lauritsen, Jeppe Vang
Linderoth, Trolle René
Lægsgaard, Erik
Meyer, Rikke L.
Mulder, Frans
Nielsen, Niels Chr.
Nissen, Poul
Ogilby, Peter Remsen
Olsen, Jeppe
Otzen, Daniel
Pedersen, Finn Skou
Pedersen, Jan Skov
Pedersen, Steen Uttrup
Revsbech, Niels Peter
Schiøtt, Birgit
Skibsted, Jørgen
Skrydstrup, Troels
Stadler, Brigitte
Sørensen, Esben Skipper
Stapelfeldt, Henrik
Stensgaard, Ivan
Sutherland, Duncan
Vosegaard, Thomas
Wendt, Stefan
Xu, Xuebing
Zelikin, Alexander



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