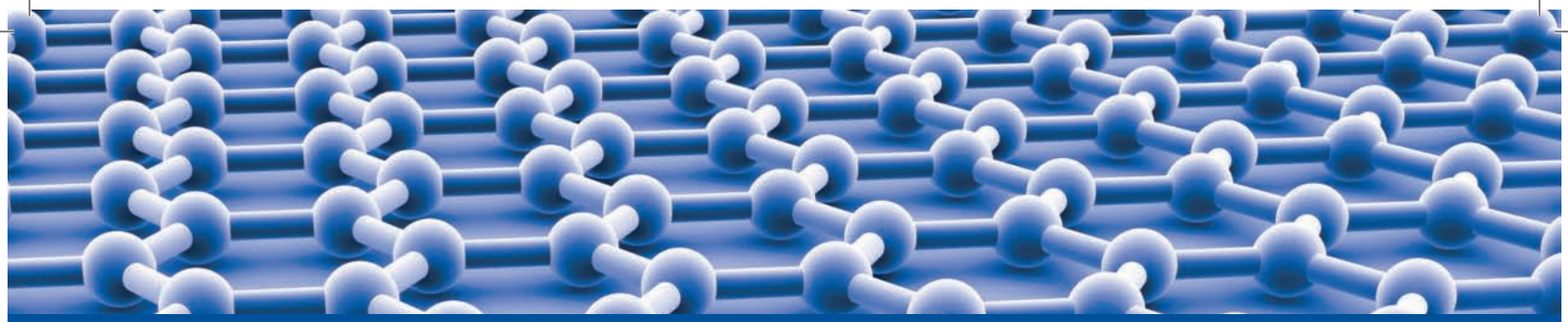
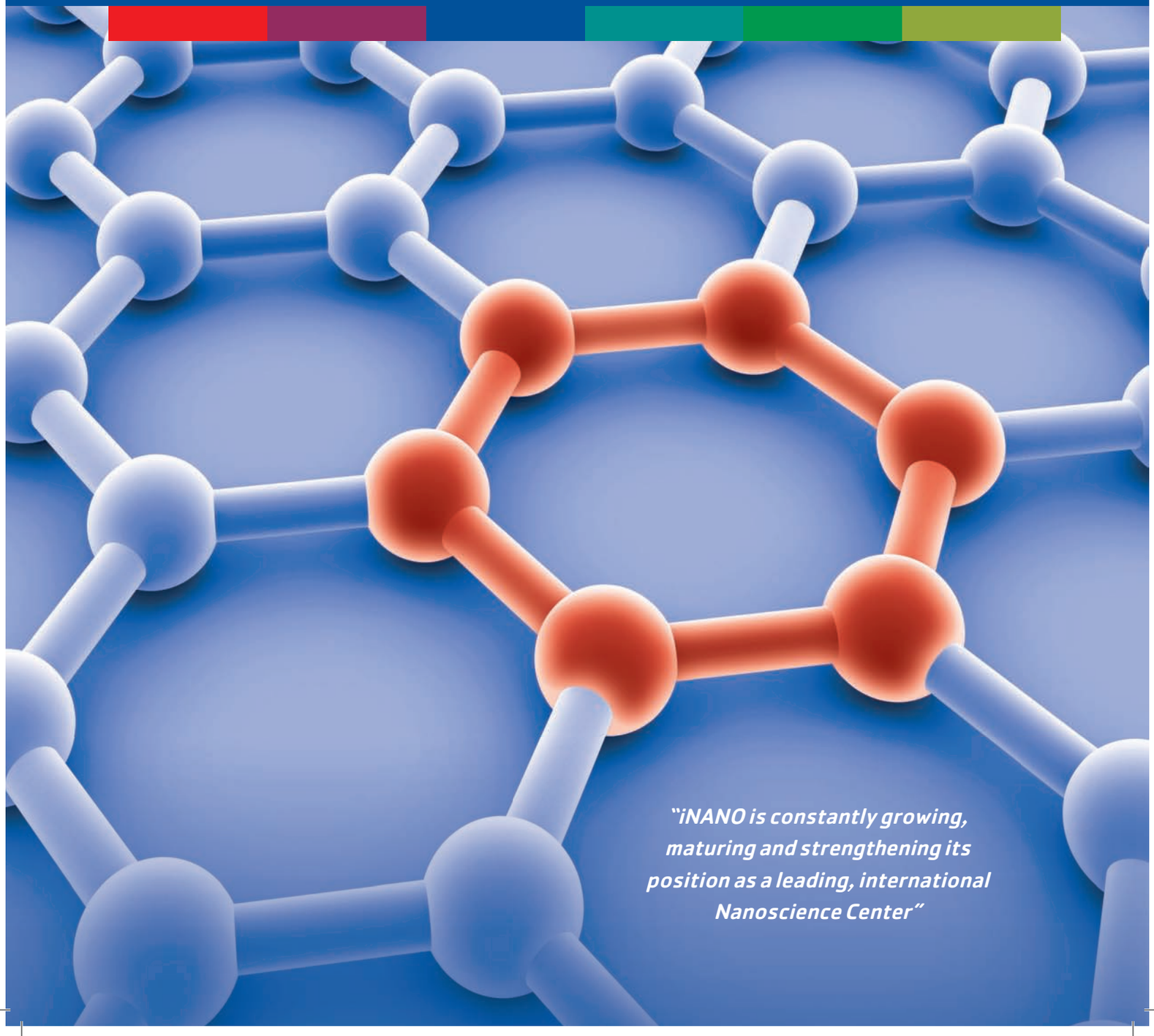


iNANO

ANNUAL REPORT 2010

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

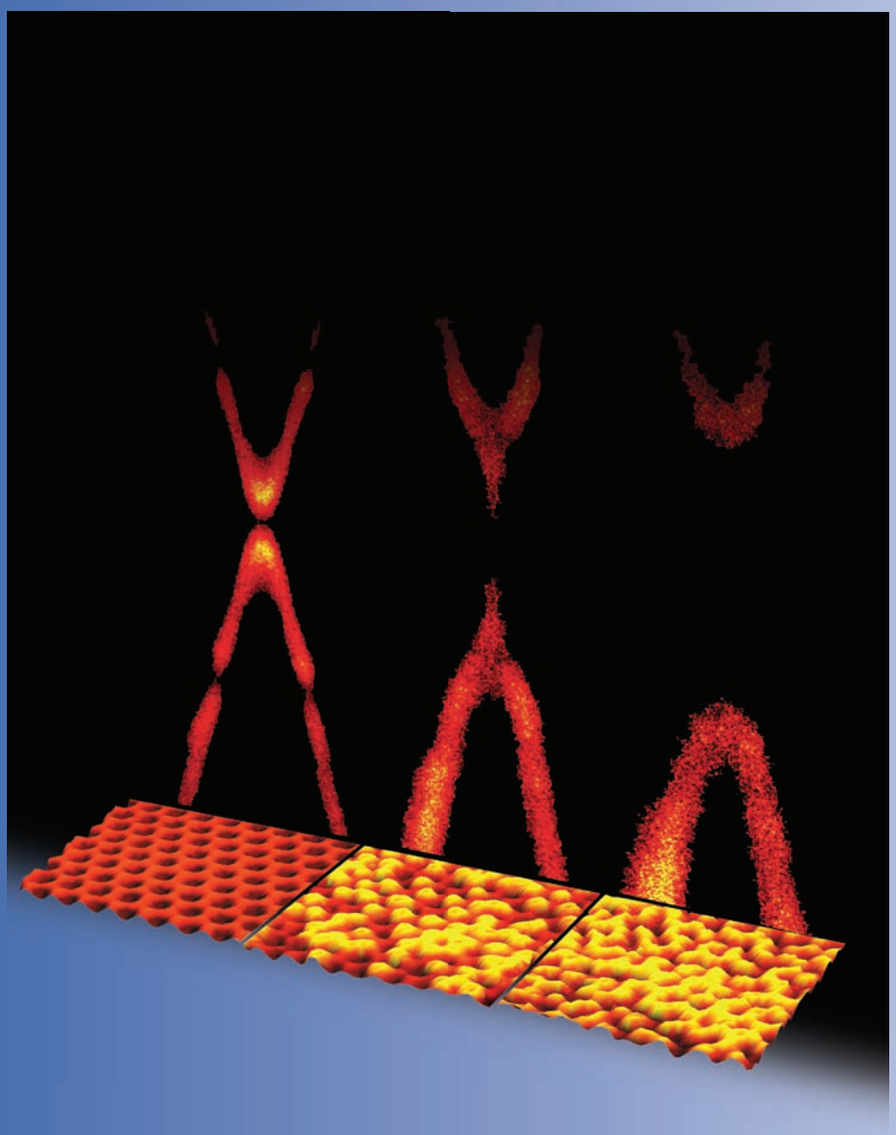


"iNANO is constantly growing, maturing and strengthening its position as a leading, international Nanoscience Center"

Graphene has the potential, on a short time scale, to be widely used in applications such as conducting plastic and high-speed electronic devices. As a recognition of its highly unusual and useful characteristics the Nobel Prize in Physics 2010 was awarded jointly to Andre Geim and Konstantin Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene". iNANO was very fortunate to have a visit from Andre Geim in January 2010 for the iNANO annual meeting; we were thrilled when the Nobel prize was announced shortly thereafter.

However, to utilize graphene in real applications a method for tunable band gap opening is necessary since freestanding graphene is a semimetal (a semiconductor with zero bandgap) where only the six charge-neutral Dirac points are present at the Fermi surface. iNANO scientists have found a method to induce such a bandgap:

Confinement induced by hydrogen barriers appears to be a promising way to control the extent of graphene conductivity, giving a possibility for large-scale electronic circuit production by H adsorption on a pre-defined pattern. STM measurements reveal spatial selectivity for hydrogen adsorption onto the graphene/Ir(111) moiré pattern leading to a structural periodic modulation of the graphene. DFT calculations show that hydrogen adsorption is stabilized through the formation of graphene-like nanostructures with relatively high thermal stability. The band dispersion of such periodically modulated graphene probed using the ARUPS technique as a function of H coverage reveals a large gap opening at the Fermi level1.



References: 1 Balog, R. et al., Band Gap Opening in Graphene Induced by Patterned Hydrogen Adsorption. Nature Materials 9, 315–319 (2010)

Content

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Message from the Director

It is a great pleasure for me to present the annual report for The Interdisciplinary Nanoscience Center, iNANO. Ever since the inauguration of iNANO in January 2002, I have been delighted to see that iNANO is constantly growing, maturing and strengthening its position as a leading, international Nanoscience Center. It is becoming increasingly difficult for me to choose which achievements should be highlighted in the annual report, as an ever increasing number of iNANO scientists is doing an amazing job with respect to research and education and within areas such as science communication to the public. To me, this clearly demonstrates that the iNANO organization is thriving and is having a large impact on the community around us.

By Flemming Besenbacher

At the end of 2010, 60 senior researchers, 59 post docs and 157 PhD students were associated with iNANO. To assist me in managing iNANO with this increasing number of associated scientists, I have an administrative staff of seven very competent and committed people helping with the day-to-day administration, planning of the iNANO graduate school and associated PhD courses, summer/autumn schools, scientific coordination, writing grant applications as well as communicating the excellent iNANO science to the public. This outstanding staff also ensures that our focus is on the iNANO mission which rests on three pillars: education, research and innovation.

Education

In 2010, about 40 new bachelor students from all over Denmark were enrolled in the iNANO Bachelor's curriculum. The fact that we are attracting students from all over Denmark is for me a clear indication that our interdisciplinary study program is very attractive for young students coming out of high school. At the end of 2010, a total of 107 bachelor students and 72 master students were enrolled at iNANO.

In late September 2010, I had the great pleasure of congratulating the first "homegrown" iNANO PhD student, Karin Dooleweerdt, who graduated after eight years of studying at iNANO, i.e. since the inauguration of the nanoscience education in September 2002. Karin's studies culminated with her PhD project entitled "New methods for transition metal catalyzed C-N bond formation. Introduction of Nitrogen Substituents onto Indole scaffolds and Amidation of Aryl Halides and Sulfonates". The project was performed under the supervision of professor Troels Skrydstrup, iNANO and Department of Chemistry. After her graduation I was also pleased to see that Karin was employed at the R&D center at Grundfos A/S where she will be developing new technologies for water treatment. I wish Karin the best of luck in her future career at Grundfos and I hope that Karin can catalyze an even stronger collaboration between Grundfos and iNANO. Since then many others from the group, nanoscience-2002-students, have finished their PhDs. We have created an alumni website where former iNANO master students, PhD students and post docs are encouraged to register.

iNANOschool

iNANOschool again experienced an increase in the number of enrolled PhD students to a total of 157. We are to a high degree fulfilling our mission of enrolling a large fraction of international students (~24%) and with a fairly high gender ratio (~35% female) of iNANO PhD students. We are currently

focusing on establishing stronger ties to leading Chinese universities and research centers via e.g. Memoranda of Understanding with some of the best Chinese universities and within the Sino-Danish University Center. (For more information on the iNANOschool see elsewhere in this Annual Report).

Research

In the past year, we have once again seen an increasing number of iNANO projects at the highest international level. A total of 332 iNANO related articles were published in a wide range of journals including high-ranked journals such as Nature Nanotechnology, JACS, Angewandte Chemie, PRL and ACS-NANO. Some of these research projects are described in detail in this Annual Report.

In addition, iNANO scientists are constantly being recognized for their outstanding achievements exemplified by the many awards and high number of grants which they have won in tough national and international competitions. In January 2010, professor Kurt Gothelf was awarded the prestigious Eliteforsk (elite researcher) award for his outstanding research in Nanoscience and DNA Nanotechnology. Brigitte Stadler, Victoria Birkedal and Alex Zelikin 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). I am particularly happy to see that these three bright, young scientists are all examples of "brain gain" to iNANO as they strengthen iNANO's international profile due to their international background. This proves to me that iNANO is indeed capable of attracting some of the brightest, young talents from all over the world.

To ensure that we will be able to conduct research and education at the international front edge in the future, in 2010 iNANO established another very important infrastructure facility in the form of the iNANO cleanroom facility. Some characterization and synthesis equipment has been installed and used already, but we are still anxiously waiting for additional tools. Our former Dean, Erik Meineche Schmidt, has played a crucial role in funding this equipment, and Erik's constant support and contribution as Dean to iNANO during the last nine years is deeply acknowledged.

In addition to the cleanroom, we are currently installing yet another new state of the art Cryo Transmission Electron Microscope, model Titan Krios, from the company FEI. It operates in the range of 80-300 kV and is the most powerful electron microscope available for 3D characterization of biological samples. The TEM is fitted with a Cs image corrector giving a point resolution of 0.14 nm, and it is the first of its kind in Scandinavia. We are all extremely excited to see the hopefully revolutionary new results, this fantastic piece of infrastructure will enable us to obtain.

Innovation and technology transfer

In 2010, the iNANO spin-out company, Nanoference, has obtained seed investment from Novo Seeds and Seed Capital to further develop the commercial aspect of the very strong iNANO science and patent platform within nanomedicine and drug delivery and in particular the chitosan nanoparticle derived systems. Until now Nanoference has engaged two full-time employees and has attracted national and international interest from big pharma companies. Associate professor Ken Howard is the CEO of Nanoference. At iNANO we constantly strive to have basic fundamental nanoscience and more strategic industry-related projects to go hand in hand. We have demonstrated that this is not an "either, or" but that these two can easily co-exist in a constructive symbiosis. At iNANO we aim to strengthen our collaboration with national and international companies catalyzed by many companies' increasing awareness about nanoscience and the possibilities it may offer to society. An important part of the collaboration is the high number of co-financed PhD programs (after the so-called 1/3+1/3+1/3 model).

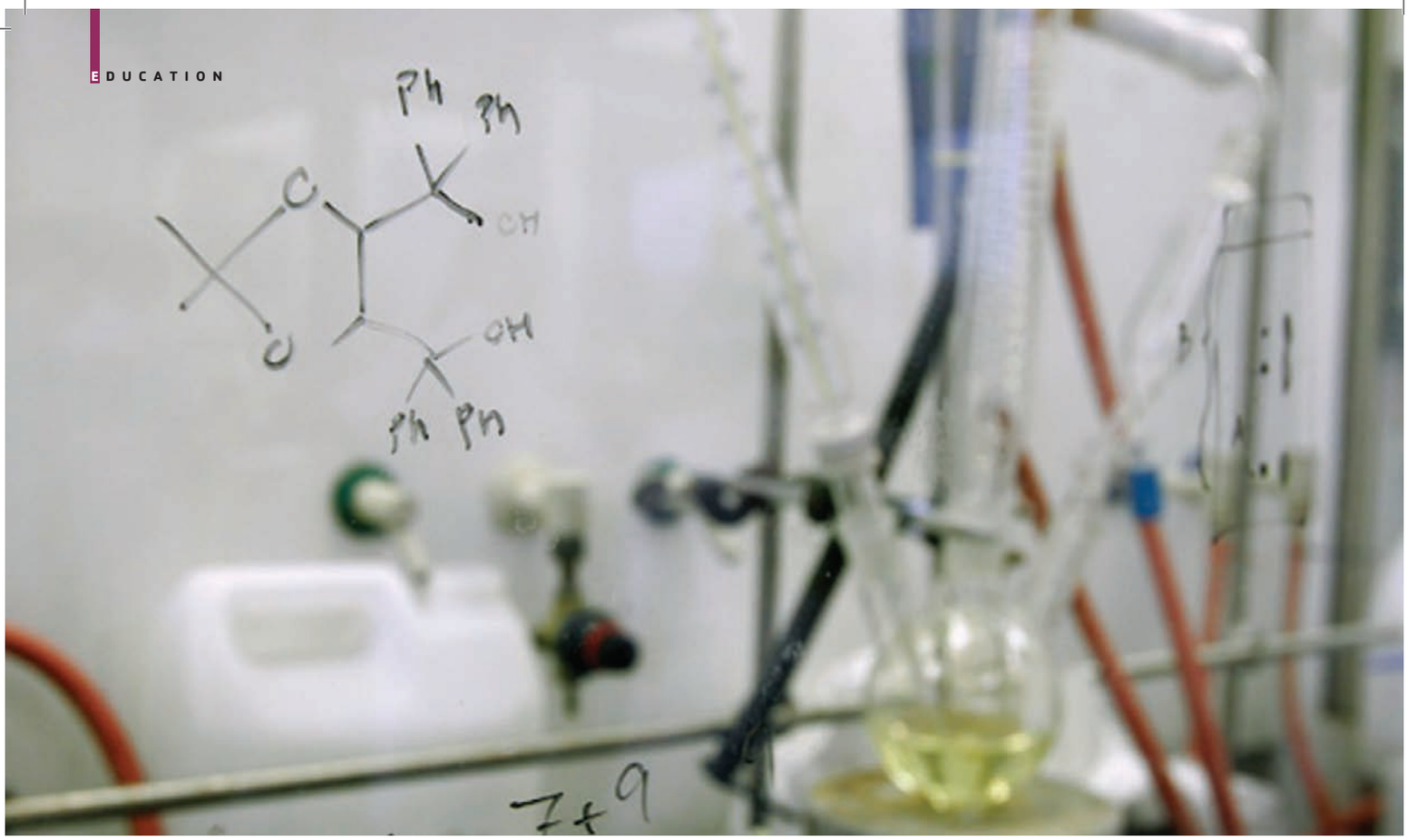
Through this University

Industry collaboration iNANO fulfills our mission with Scientific Social Responsibility (SSR) and our overall responsibility to conduct applied and fundamental research which aims at helping society to meet with some of the most important Grand Challenges the world is facing in the 21st century.

Outreach

Also in 2010, we have felt a great responsibility for communicating nanoscience to the public both through newspapers, TV and the internet. Several iNANO researchers were featured in articles in national newspapers and in national news broadcasts.

With this strong iNANO platform, I am extremely optimistic with respect to the future of iNANO.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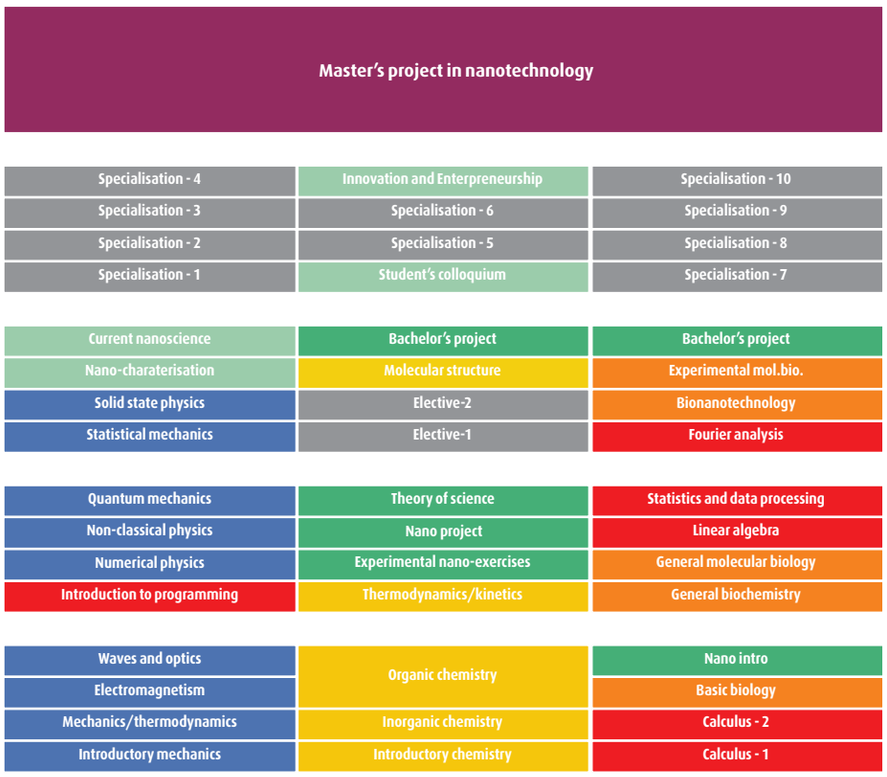
An interdisciplinary curriculum for Nanoscience

By Trolle Linderoth

Interdisciplinarity lies at the core of nanoscience and nanotechnology. Many of the most groundbreaking current developments take place at boundaries between the traditional disciplines of physics, chemistry, molecular biology and biology. This observation, along with the fact that the years of undergraduate education to a large extent define our mental framework and approach to science, 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 has counted 40-60 highly motivated and dedicated young students. In 2010 the Bachelor's and Master's programmes in Nanoscience underwent an accreditation process. Here they were thoroughly examined by the accreditation institution ACE Denmark on 10 criteria for quality and relevance falling within four criteria pillars (i) the labour markets demand for the programme, (ii) quality of the underlying research environment, (iii) structure and organisation of the study programme, and (iv) results of the study programme. The iNANO nanoscience education received the best possible rating, which is unusual, and was accredited for 6 years.



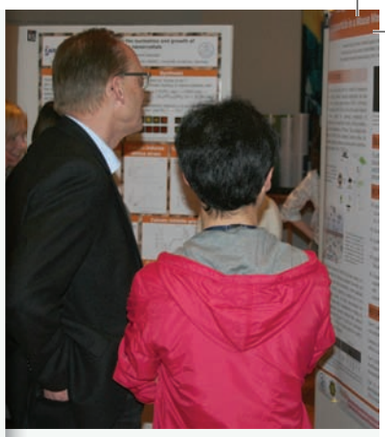
Course programme for the interdisciplinary Bachelor's and Master's degree in nanoscience offered at iNANO in 2010. Each academic year (starting from the bottom) is divided into four 7-week quarters and typically three courses are followed in each quarter. Legend: blue: physics courses, yellow: chemistry courses, orange: molecular biology courses, red: mathematics/computer science courses, green: nanoscience courses, grey: specialisation modules.

Bachelor's programme

During the first three years, students receive basic interdisciplinary training in physics, chemistry, biology, molecular biology, mathematics and computer science. Many of the 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 and 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. 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 terminated by an individual Bachelor's project.

Master's programme

During their Masters study students are required to specialize in either of three different fields: nano-physics, nano-chemistry or nano-molecular biology. In doing so they choose from the extensive course catalogue at the Faculty of Science and follow course programmes developed through individual counselling. 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.



Graduate studies

iNANOschool

With currently 157 PhD students enrolled, iNANOschool has developed into a nanoscience graduate school of international stature. A broad range of specialized graduate courses has been established, and iNANOschool students have access to highly advanced research facilities. The iNANOschool provides interdisciplinary competences in nanoscience and nanotechnology at the highest international level.

By Kaj Jensen

iNANOschool (inanoschool.au.dk) was established in 2002 with the objective of educating highly qualified, internationally competitive PhDs in interdisciplinary competences in 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, nano-energy-materials, nanomedicine, self-assembled molecular nanostructures, nanofood, nanophotonics and -electronics, and nanotoxicology. Overall, the research activities are at the international forefront of science and serve as an ideal framework for education and industrial collaborations. Besides research, iNANOschool offers a broad range of PhD courses within nanoscience and nanotechnology and provides facilities for and supervision of an increasing number of PhD students. During 2010, 43 new PhD students were enrolled in iNANOschool and 32 PhD students completed their PhD studies. In addition to the focused PhD courses, activities include a major annual meeting, an autumn school, student networks, and initiatives to promote the exchange with other international institutions.

Courses in 2010

Since its establishment, an important task for iNANOschool has been to educate the students in high priority research fields together with innovation, commercialization and ethical aspects of nanoscience and nanotechnology. Most courses are offered as intense one- or two-week courses to ensure that the interference between attending the course, doing research or even going abroad is kept to a minimum.

During 2010, iNANOschool offered the following courses: Science based Innovation and Entrepreneurship, Drug Delivery, Bionanotools and Protein Structure, Advances in Amyloid Science, Nanooptics, Self-assembly of Molecular Nanostructures and the annual iNANO Autumn School.

Three courses, Bionanotools and Protein Structure, Drug Delivery and Innovation and Entrepreneurship, were held at Aarhus University. Bionanotools and Protein Structure was held 16-20 August and the purpose of the course was to introduce the students to a number of analytical measurements and analytical tools used for the structure-function analysis of biological macromolecules, or biological nanomachines such as functional proteins, membrane pumps and channels. The aim of the Drug Delivery course was to provide insight into theory and technical requirements for delivery of nucleic acid-based gene silencing therapeutics in established cell lines, primary cells and animals. The course, Innovation and Entrepreneurship, was held on eight days in April and May and focused on a broad knowledge of the basic concepts of innovation and entrepreneurship. The course, Advances in Amyloid Science, was held at the Fuglsoecentret 27-29 September at Sandbjerg Gods. The formation of protein amyloid has attracted a great deal of attention due to its association with widespread neurodegenerative diseases such as Alzheimer's and Parkinson's. The course dealt with different aspects including mechanisms of amyloid formation, detection and inhibition of amyloids and amyloids as nanomaterials.

On 7-12 August the Sandbjerg Estate was used as the venue for a course in Self-assembly of Molecular Nanostructures covering topics such as self-assembly of organic molecules, protein fibrillation, design and assembly of DNA nanostructures and applications thereof. The lectures at the summer course was given by leading international scientists and provided local and international students with a unique perspective on our current understanding of molecular self-assembly and DNA nanostructures. The summer school was hosted by iNANOschool in collaboration with the Chinese National Centre for Nanoscience and Technology (NCNST) in Beijing.

In addition to the above mentioned courses, courses in Nanooptics and the annual Autumns School were held at the Fuglsoecentret. The Nanooptics course was held on 3-7 September. The program consisted of tutorial lectures delivered by invited leading, international experts, student exercises and poster presentations by the attending students.

iNANO Autumn school 2010

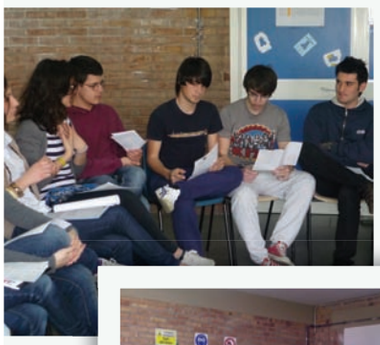
A recurrent event in the iNANOschool calendar is the iNANO Autumn School, where all PhD students enrolled at iNANOschool are brought together for a series of workshops and different types of presentations during an extended weekend at the Fuglsoecentret.

Again this year, the overall theme was non-scientific and focused on career developing tools for the PhD students. Nine excellent speakers from different areas of our society were invited to present topics such as Writing for Publication, Writing Grant Applications, Leadership Tools, Scientific Social Responsibility and a Workshop on Different Personalities. From the feedback given by the participating PhD students it appears that this year's topics were well chosen and highly useful for the PhD students.

In addition to the overall topic, the students presented their research project either as an oral presentation or in a poster session. The intention is to catalyze discussions and stimulate collaboration among the students on the research activities. The PhD students receive feedback on their oral presentations and there is a competition for both best oral presentation and best poster.

Life after graduation – launch of a new mentor program

iNANO and AGSoS have launched a mentor program, The Science Mentor Program, with the aim to help 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 Science Mentor Program was initiated by three iNANO PhD students, Line Holdt Rude, Louis Nilsson and Thomas Nørregaard Jensen motivated by their own curiosity towards their future career. First applications for mentors were received in December 2010 and a number of matches have already been formed. Some of the current mentors are Lone Frank, author and science writer, Jens Gundersen, director of Unisense and Elisabeth V. Carstensen, director of pharmaceutical operations at TopoTarget. The main purpose is that The Science Mentor Program can facilitate a bridge of knowledge and experience between the University and the industry.



NANOYOU:

A nanotechnology education resource

By Luisa Filipponi

A recent survey[1] has shown that "Nanotechnology" is a word mostly unknown to the majority of European youngsters aged 11-18. Those who have heard the word cannot define it precisely and they often associate it with products like the iPod Nano. Despite their poor knowledge, when given examples of concrete applications enabled by nanotechnologies, youngsters are enthusiastic about it and want to know more, however, they are also aware of potential risks and societal considerations. The NANOYOU project was established precisely to address this interest by increasing young people's basic understanding of nanotechnologies and by engaging them in the dialogue about its ethical, legal and social aspects (ELSA). The project is coordinated by ORT Israel and the participants are: European Schoolnet, Interdisciplinary Nanoscience Center (iNANO), The Nanoscience Center of the University of Cambridge, Barcelona Science Park, The Centre for Social Innovation, Centre de Culture Scientifique Technique et Industrielle de Grenoble, La Cité des Sciences et de l'Industrie (Universcience) and Halevi Dweck & Co. ARTTIC Israel Company Ltd (project management).

Since its establishment in April 2009, NANOYOU (www.nanoyou.eu) has produced a wide range of educational materials for different age groups, such as videos, posters, memory games, virtual experiments and virtual dialogue games, experiments for schools, a role play game and more. The contribution of iNANO has been pivotal throughout the development of four simple experiments, which can be done in schools, a very comprehensive teachers' training kit and a 400-pages e-book describing the fundamental concepts in nanotechnologies as well as their applications of nanotechnologies. The teacher kit will soon become an EC publication and a reference document for teachers and educators.

Fifty schools across Europe were selected as "pilot schools" and more than 300 schools were involved in an intense outreach program. Teachers from pilot schools were offered a two-day teacher training on nanotechnology and on the NANOYOU programme including live experiments and hands-on activities. The feedback from teachers and students has been enthusiastic, and numerous schools have indicated their interest in including nanoscience in their school curricula, the lab activities in particular.

In addition to the school outreach program, NANOYOU has developed a travelling exhibition that deals with the applications of nanotechnologies in the Information and Communication Technology sector and with the ethical aspect that might be involved in these applications. The exhibition is called " All connected?" and targets the older age group, 18-25 years of age. It includes videos and photos which have been produced by youngsters involved in the project. In March 2011, the exhibition moved to Paris (Universcience) where it will stay until the end of the year 2011.

[1] *"Knowledge, Attitudes and Opinions on Nanotechnology across European Youth", European Commission, 2010*

Nanorama – Student organization

By the Board of Nanorama

Nanorama is the organization representing the students at iNANO. The organization was established in the spring of 2005 and is run solely by students. By arranging different social and educational activities, such as Friday bar, company visits, and iNANO student teams joining the annual Aarhus 1900 relay race, we hope to make everyday life for each student at iNANO a great experience.

Nanorama aims to promote contact between students from different year groups and to give the students a broader perspective with respect to their possibilities after their Nanoscience education at iNANO. We wish to achieve this by arranging social as well as educational activities each year.

The board of Nanorama consists of seven students representing different year groups. To attain efficient schooling of new members to the board, these are elected by other students twice a year, thereby allowing a time overlap between new and more experienced board members. In 2010, Nanorama arranged a wide range of activities including iNANO student teams joining the annual Aarhus 1900 relay race, Friday bars, and the traditional birthday party. In addition, we arranged a series of lectures where nanoscience graduates told about their careers inside and outside of academia after graduating from iNANO. We believe that if students are aware of their possibilities after graduation, they will be even more encouraged in their studies. Furthermore, we arranged an end-of-year day with social activities to establish bonds between the different year groups and where students could see each other in a relaxed atmosphere before leaving for the summer break.

The current board members will continue the work of Nanorama until the beginning of 2011, and several events are on the drawing board. The new initiatives include Friday lectures where scientists at iNANO will talk about the research which is currently being conducted in their research groups. There will be three lectures per quarter representing all three main areas in nanoscience: biology, physics, and chemistry. In this way, the students can be inspired before choosing scientific direction.

Anders Okholm

Marie Krogsgaard

iNANO student funding

In 2010, iNANO students have attracted considerable funds supporting their nanoscience studies

By Leif Schauser

Students, who wish to spend some time abroad as part of their studies, who wish to boost their Master's or PhD research with external grants, or who simply prefer not to have to worry about student jobs while still maintaining a high standard of living, have numerous opportunities when it comes to funding. Many top iNANO students have utilized their extraordinary results achieved during their nanoscience studies to attract funding from a range of sources. In total, they have raised more than DKK 700,000.

Sources of funding

The Danish Cancer Society
The Novo Nordisk Foundation
Danish Research Agency
Professor Hakon Lund and Lektor Hans Rasmussen's Foundation
The Aarhus University Research Foundation
The Oticon Foundation
The Knud Højgaard Foundation
Henry Shaw Ozark Corridor Foundation
The Carlsberg Foundation

They received grants

Marie Krogsgaard received a grant from Novo Nordisk and Novozymes for working on her thesis: "Mussel Inspired Potential Tissue Adhesives: Synthesis and Characterization" under the supervision of associate professor, Henrik Birkedal. The purpose of the scholarship is to allow the recipients to concentrate full time on their Master's thesis. "Receiving this scholarship allows me to focus solely on my Master's thesis and I do not have to worry about my personal finances. In addition, I consider it a great honor to be selected among many other postgraduate students from all over Denmark", says Marie Krogsgaard.

Anders Okholm was enrolled as a visiting fourth year student at Columbia University for the 2010 fall semester. "It was clear, that at the world's most expensive university the students are 100% committed to their studies. The workload was significantly higher at CU than at home. During my stay, I learned many new academic terms and activated my otherwise passive vocabulary. All in all, it was a fantastic experience, which I would recommend to anyone who gets the opportunity. My semester at Columbia has motivated me for my future PhD project where I will return to New York City", says Anders Okholm.

"I am particularly pleased to see the high number of grants that our nanoscience students have been able to attract, and I think it shows that we have a lot of exceptionally talented, young students with strong drive who take charge of their own careers", says professor and director at iNANO, Flemming Besenbacher and continues "I strongly encourage other students to follow their example and apply for scholarships to either go abroad or to allow them to focus on their studies".

iNANO study tour 2010

In 2010, as in previous years, iNANO students who had just finished their second-year nano-science studies went on a week-long 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.

By Simon Frølich

The destination of this year's study tour was Scotland. A visit to three great nanoscience research environments at the universities of St. Andrews, Edinburgh and Glasgow, respectively, was made possible, thanks to the generous support from the Tuborg Foundation and the H. C. Holst Foundation. Leif Schauser, scientific coordinator at iNANO, arranged the scientific program, and a student committee helped with the fund raising and organization of hostels and cheap Ryanair flight tickets.

Most students took the opportunity to experience Scotland and extended the stay by a few days to enjoy each other's company at a short team-building vacation in Edinburgh and to explore the city, its surroundings and nightlife.

The scientific programme began on the 22 June where we visited the University of St. Andrews. Here, researchers gave us some very inspiring lectures in nano-lithography, nano-catalysis, chemistry for LED technology and protein crystallography. In addition to lectures, we had an exciting tour through the laboratories and a great lunch in the university canteen followed by a short stroll to the sunny beach which is located at the famous Old Course where golf has been played for over 600 years. In the late afternoon, exhausted from a long day of scientific input, we received one hour of golfing instruction at the Castle Course, before heading back to Edinburgh.

The next day we visited the Scottish Microelectronics Centre at the University of Edinburgh. Here, we received an introduction to some of the main research interests and industrial collaborations of the Centre and the nearby chemistry department. We also visited the clean room facility where the semi-conductor research is carried out.

On the final day of the scientific program, we visited the University of Glasgow. As a graduation ceremony at the very elegant main campus buildings of the university requires the graduates to wear robes, hats and wands, we almost felt like being at Hogwarts School of Witchcraft and Wizardry. At the university, we listened to fascinating presentations on biologically oriented nano-science research. A Danish researcher now working in Scotland was one of the speakers. He took us on a guided tour through campus and showed us their research as well as clean room facilities. Unfortunately, one of our fellow students got instant fame as he took flash pictures in the clean room, well aware that clean rooms are used for light-sensitive photo-lithographic processing.

With the academic program completed, the Glasgow hosts invited us to an Indian restaurant where we enjoyed some great food before we went to a church-turned-pub. Here, we changed to red-and-white and watched a widescreen transmission of the World Cup football match between Denmark-Japan. Unfortunately, Denmark lost 1-3 and we returned back to Edinburgh to "celebrate" before flying home on the following day.

Talent transfer

Kick-started in September 2009, the joint Sino-Danish Research Center is a collaboration between iNANO and three Chinese elite research institutions: the National Center for Nanoscience and Technology (NCNST), Beijing, Peking University and Tsinghua University, also Beijing. The activities are funded by the Danish National Research Foundation and focus on synthesis and characterization of molecular nanostructures on surfaces. In addition to research, the Center is a facilitator for valuable transfer of knowledge and exchange of talented young researchers between the Danish and Chinese research environments.

Research Center co-director Flemming Besenbacher says: "I have travelled in China for 25 years and have witnessed the country's amazing transition to a strong research nation. Denmark has rightfully chosen to direct focus on China and one concrete manifestation is our joint Research Center which gives us the opportunity to interact very closely with strong Chinese research groups, for example through exchange of personnel."

Jacob Cramer and Lei Liu have both participated in the exchange student program as part of their academic careers.

By PhD student Jacob Cramer

In the fall of 2010, I had the pleasure of studying at the National Centre for Nanoscience and Technology in China. The centre is perfectly situated in the northern part of Beijing between the prestigious Tsinghua University and Peking University.

I was involved in the studies of peptides, which aggregate into neurotoxic plaques in the brains of Alzheimer's disease patients. The aggregation mechanism can be affected by organic molecules, which specifically bind to the peptides resulting in a decreased cytotoxicity. With a background as an organic chemist, I synthesized molecules of interest and in close collaboration with the Chinese PhD students I investigated how the organic molecules affected the aggregation mechanism of the peptides. During the studies, the Chinese students were incredibly helpful and very interested in discussing both scientific as well as non-scientific topics, which resulted in many productive conversations. Moreover, due to our complementary competences we obtained some exciting results. The students, and Chinese people in general, have great patience with foreigners, who often have different traditions and typically do not speak the language. It is therefore advisable to be patient yourself, even though this can be a challenge from time to time.

Usually, the students eat lunch at the affordable student canteens. Due to the long working days, dinner is often purchased here as well. Another option is to enter one of the numerous restaurants found all over the city. Tasty traditional dishes containing rice or noodles accompanied with green vegetables are served many places. The popular Peking Duck should, however, not be missed. When eating at restaurants, the meat and vegetable dishes are laid out all at once in the center of the table, and the diners eat directly off the communal plates using their chopsticks. Beverages are not commonly served with a meal, and a thin soup is usually the only liquid provided.

As a foreigner you are expected to work more than most Danish students are used to. However, you are also strongly encouraged to go sightseeing. The Chinese students are eager to show you the different tourist attractions such as the Forbidden City and the Great Wall. This is a nice opportunity to explore the historical sites while having interesting discussions with the students.

Beijing has a population of almost 20 millions, and the city is a metropolis. Being a foreign researcher is a great chance to explore Beijing and the fascinating Chinese culture on your own. Personally, I think it has been a unique opportunity to collaborate on a joint research project, while experiencing China from the inside.

By Postdoc Lei Liu

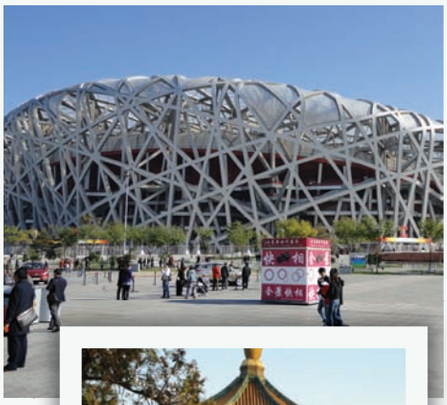
I commenced my current position as postdoc at the iNANO Center in late 2010. It was just after my graduation from the National Center for Nanoscience and Technology of China (NCNST). The NCNST is co-founded by the Chinese Academy of Sciences (CAS) and the Ministry of Education and it was officially founded on December 31, 2003 with CAS, Peking University and Tsinghua University as its initiators and co-founders. Currently, the NCNST mainly consists of the following scientific branches: laboratory for nanodevices, laboratory for nanomaterials, laboratory for biological effects of nanomaterials and nanosafety and laboratory for nanocharacterization and nanostandardization.

During my PhD project I focused on peptide assembly and the modulation effect on these assembled structures. In addition, I focused on biological functions of peptides which are closely correlated to different neurodegenerative diseases such as Alzheimer's disease. The main techniques used were Scanning Probe Microscopy (SPM), which was used to explore the molecular assembly structures on different surfaces, as well as other spectroscopy methods used for detecting the aggregation behaviors of peptides in solution. I completed my project by designing molecules that could modulate the amyloid peptide assembling structures and its cytotoxicity to neurons.

After my graduation from the NCNST, I came to Denmark due to the opportunities made possible by the Sino-Denmark collaboration project. This collaboration had previously sent several students to Denmark for 3 or 6 months as part of the exchange student program. I was, therefore, pleased to be offered the chance to come to iNANO and continue my research. Since my arrival to Aarhus University I have become aware of new, interesting interdisciplinary research areas which are currently going on at iNANO and which I find truly inspiring.

In addition to the exciting science, I find the city of Aarhus to be a very comfortable place to live. You can enjoy the quiet life in your home or go out and experience the liveliness of the downtown. I feel that everyone here is nice and friendly to you. In particular, I enjoy the different outdoor sceneries including the beautiful beaches and the famous Old Town of Aarhus. But the people here have made the biggest impression on me. I have already made several friends, some of whom I will cherish when I return to China.

In conclusion, I would say that doing research in Denmark was a great move for both my career and also for me as a person, and I would definitely recommend it to everybody.



Graduation of the first

all-iNANO PhD students

In the summer of 2010, the education in nanoscience and -technology at iNANO could celebrate its 8th anniversary. The interdisciplinary Bachelor's and Master's programs in nanotechnology, which were introduced at iNANO in 2002, were the first of its kind in the world. Eight years later, in the fall of 2010, the first all-iNANO PhD students completed their studies.

By Jonas Ørbæk Hansen and Esben Kjær Unmack Larsen

In 2002, the first Bachelor's and Master's programs in nanotechnology in Denmark (Europe, World?) were established at iNANO. Even though nanoscience and -technology was more or less unknown to most people at the time, 38 young students including the two authors of this article commenced the new education. We all came with a pioneering spirit. This was a new type of education covering many different topics and scientific fields, but with one focus: Nanoscience.

Great effort was made to create an excellent education both in terms of putting together an exciting, interdisciplinary course program as well as creating a great atmosphere for learning. We got our own class rooms furnished with completely new, comfortable chairs, computers and projectors, and a new Friday café was introduced where we could do our homework with help from our instructors and lecturers. It was an exciting time. Our education comprised a variety of scientific disciplines including mathematics, physics, chemistry, computer science, biology, molecular biology and health science, so we learned a lot about many different topics.

A large part (39 %) of the 38 students commencing the Bachelor's program in nanotechnology was later on admitted to the iNANOschool to do a PhD in nanoscience/-technology (see box). The PhD projects spanned widely covering many different topics in nanotechnology: from the preparation and study of catalytic structures, smart nanofiber fabrics, DNA origami and optic fibers to targeted drug delivery by nanostructures, just to name a few. In September 2010, the first all-iNANO student, Karin Dooleweerdt, completed her PhD studies (see box). Since then, the rest have either completed their PhD studies or are very close to completion.

Most other students from that year graduated with a Master's or a PhD degree from either iNANO or related fields at the Faculty of Science. They are now employed in different types of jobs including scientific work with bakery and cereal technology at Danisco, account manager at Bio-Rad Laboratories and controlling what paint to use on ships (Maersk).

Many of the current, most cutting-edge progresses in research and development take place at the boundaries of the traditional scientific disciplines and therefore, we believe that the versatile and interdisciplinary education in nanoscience has prepared us very well to meet the challenges that a future position will bring, whether this is in academia or industry. We hope that many others will follow in our footsteps and gain, what we believe, is an interesting and exciting education.

Year group 2002 – degrees:

39 % PhD in nanoscience/-technology
11 % PhD in related fields at the Faculty of Science
16 % Master in nanoscience/-technology
13 % Master in related fields at the Faculty of Science
21 % Unknown/did not graduate

Karin Dooleweerdt was the first iNANO student to complete her PhD studies. She did so in September 2010. Now, she is employed in the research department at Grundfos where she works with design and development of new, functionalized and smart materials for use in connection with water treatment and cleaning which is a relatively new business area at Grundfos. Karin is also involved in the development of ideas for new products and markets for Grundfos. Here the interdisciplinary background from iNANO is very valuable, especially when presenting new ideas for people with very different backgrounds within Grundfos and to partners outside the company. "The general and broad knowledge of many different scientific fields, tools and techniques that the education in nanotechnology has given me, is a great advantage in my daily work at Grundfos. It has made me more open to tasks outside my own area of expertise and has enabled me to understand issues different from my usual field of work", Karin says.

9th iNANO annual meeting 2011

By Peter Thostrup and Sys Zoffmann Glud

The 9th iNANO annual meeting took place on 19 January 2011 as a whole-day event with 6 invited lectures, a poster session with an impressive 101 poster contributions and an evening dinner. Also this year, iNANO managed to attract high-profile speakers from around the world who delivered inspiring talks on nanoscience topics.

Global Challenges and Nanofibers

Professor Seeram Ramakrishna, Vice-President (Research Strategy), National University of Singapore, set the scene by explaining how and where scientists can contribute to meeting today's global challenges such as quality living for growing urbanities (an obvious concern in Singapore), affordable healthcare, food security and nutrition, affordable clean energy, and quality water supply. Concerning the latter challenge, prof. Ramakrishna mentioned that Singapore is actually moving towards a 100% closed water cycle.
As to the energy challenge, prof. Ramakrishna stated that research shows that no matter what happens in the world, electricity consumption always increases. As a physicisist or engineer, our job is thus to find a way to supply large amounts of electricity at a lower price. Here it is important to note that no one single energy source will be sufficient but that we need all production forms to supply the energy needed.

In his scientific part, prof. Ramakrishna described his own research in electrospinning of nanofibres, which have a wide range of applications. Nanofibres have a number of advantageous properties: first of all, they are produced with "green" processes and without toxic solvents. For solar-cell applications, their high surface area and the ease of incorporating solar-harvesting compounds, such a dye sensitizers, are both highly desirable.

In the field of regenerative medicine, nanofibres can be used to construct for instance grafts with nanofibre conduits for nerve regrowth. Other applications in development include skin grafts, breast-conserving grafts, and nanofibres patches for replacing heart tissue after a myocardial infarction.

Minigene control systems

Jumping now to control in cellular biology, Assistant Professor Christina D. Smolke from Stanford University gave a talk on Programming living systems with RNA. Cellular communication consists of complicated signaling pathways involving molecules that sense the presence of a changed state, molecules that transmit this signal to other molecules and molecules that take action upon a certain signal. "In a sense, cellular behavior is controlled much like a computer device composed of sensors, transmitters and actuators", explained Christina Smolke.

Along this line the research of Christina Smolke is centered on development of molecular switches into synthetic and endogenous cellular networks and RNA-based switches as molecular recognition components of nanosensor devices. She reported on studies showing how protein-responsive RNA aptamers placed in key intronic locations of a gene transcript can alter the splicing pattern in response to nuclear protein levels resulting in expression of for instance a fluorescent marker protein. Recently, her group has elaborated these synthetic RNA-based genetic control devices further to include ribozyme switches which in T-cells can convert a small-molecule input to an increased cytokine expression output. The system design ensures suppression of cell growth as a default

From the left: Prof. Andrew Turberfield, Prof. Anthony J. Ryan, Anthony K. Cheetham, Assistant Professor Christina D. Smolke, Prof. Ijeoma F. Uchegbu, Prof. Seeram Ramakrishna and Prof. Flemming Besenbacher

state and induction of cell proliferation only in the presence of an administered small-molecule drug input. By providing tight gene-expression control with customizable ligand inputs, RNA-based regulatory systems can greatly improve cellular therapies and advance broad applications in health and medicine.

Anthony K. Cheetham, Department of Materials Science and Metallurgy, University of Cambridge, gave a talk entitled "Inorganic-organic framework materials; there's plenty of room in the middle". Prof. Cheetham has a glorious career that for instance brought him to University of California at Santa Barbara where he was the founding director of the Materials Research Laboratory.

Now back at the University of Cambridge, prof. Cheetham's research focuses on hybrid nanomaterials, i.e. materials which combine organic and inorganic components. Inspiration to designing and synthesizing hybrid nanomaterials can be drawn from nature where materials such as bone or mussel shell are abundant and hybrids between inorganic and organic components.

Prof. Cheetham spoke mainly of his research in so-called ZIFs, analogues to Metal-Organic-Frameworks (MOFs). In ZIF, the Si-O-Si linkage known from MOFs is replaced with Zi-imidazole-Zi link. Research has shown that 30-40 different ZIP topologies exist, largely determined by the ligand to the imidazole moiety, and that ZIF topologies can be mapped onto known MOF topologies. The Cheetham group has characterized the mechanical properties of nanoporous and dense ZIFs and demonstrated that the porous morphologies are much softer than dense ones. During these studies, the group has surprising found that upon simple heating, all unsubstituted ZIFs go through an amorphous phase but then recrystallizes at even higher temperatures to a dense ZIF. Towards the end, prof. Cheetham discussed his activities in MOFs, which have been named excellent candidates for hydrogen storage but difficult compromises have to be made between cavity size and surface area. Research also shows that physisorption on the surface of cavities is too weak. Instead, prof. Cheetham's group follows an alternative strategy, which employs unsaturated metal sites inside the cavities.

Professor Anthony J Ryan, Pro Vice Chancellor, Faculty of Science, University of Sheffield, gave a very entertaining talk named "Making nanoscale capsules and swimmers". Prof. Ryan has been strongly involved in science outreach and indeed demonstrated very vividly to the audience why he is held in such high regard for these contributions. Prof. Ryan strongly objected to the public image of nanotechnology as being capable of constructing a submarine swimming through a blood vessel to seek out and kill diseased cells. Instead, he talked about the real situation where the movement of small objects through water is not dominated by inertia but by viscosity. It turns out that a realistic medical "nanobot" would be bio-inspired, i.e. it would be soft, wet, and asymmetric.

The asymmetry is in prof. Ryan's case introduced in the form of block co-polymers, which can be brought to assemble in "polymersomes". Different methods can give you sizes from microns to a few nanometer. Two particular examples were covered: First, prof. Ryan has succeeded in constructing a block copolymer with both a permanently hydrophilic twitterion (phosporylchorine) and a poly-base, which is switchable with pH. The poly-base can also bind to DNA and drag it into the vesicle upon vesicle formation and can thus be used for DNA transfection. Second, prof. Ryan showed an example of a synthetic muscle, which is a molecular device to translate chemical energy into mechanical work. This particular type of synthetic muscle was self-assembled from block copolymer and reacts to changes in pH caused by a so-called Landolt oscillator, an oscillating chemical reaction, which causes expansion and contraction of the polymersomes, thus translating chemical energy into mechanical work.

Molecular machines from DNA

An enthusiastic Andrew Turberfield, professor from Department of Physics, Oxford University, began his talk by sharing his thought about what a wonderful material DNA is for doing inspiring interdisciplinary and collaborative projects on engineering of molecular machines or nanorobotics! DNA nanotechnology makes use of the exquisite self-recognition of DNA in order to build on a molecular scale. Depending on the length DNA helixes have different properties; short, less than 50 nm, helixes are stiff and unflexible whereas longer helixes become gradually softer and bendable. DNA is ideal for construction of self-assembled 3D structures that can easily be designed using the intrinsic properties of Watson-Crick base-pairing and the can even be made capable of movement. However, active control of such movements is a prerequisite for applications of 3D DNA architectures in a biological setting such as for nanomedicine. In his talk, professor Andrew Turberfield described how he and his people had built DNA tetrahedra with controllable cage opening in response to molecular signals. Using FRET opening and closing of the tetrahedra was demonstrated by fluorphores, that were quenched in the closed state.

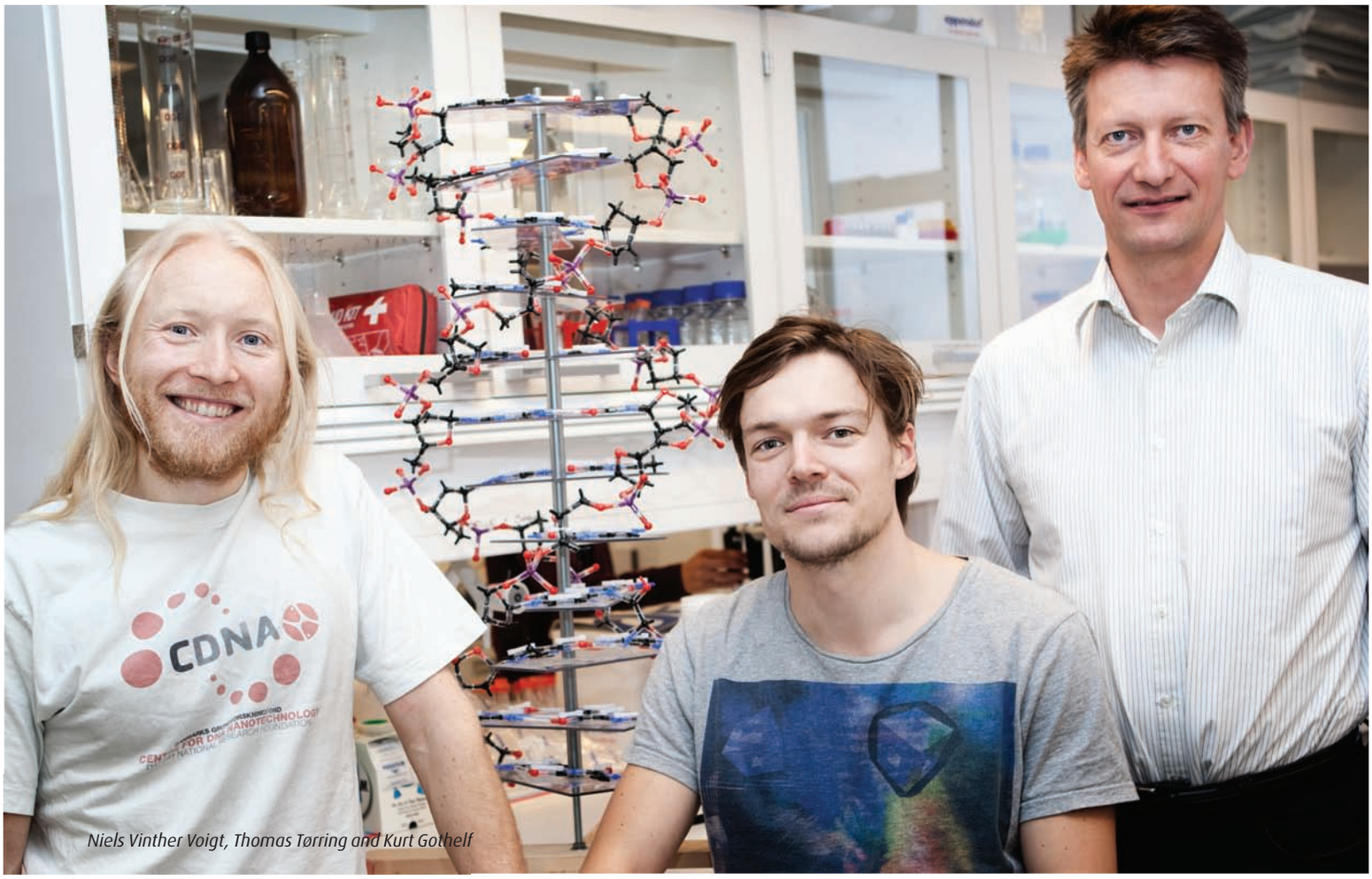
Inspired by the cellular motor protein, kinesin, which walks along the cells microtubule powered by the hydrolysis of ATP, Andrew Turberfield demonstrated his very recent development of a molecular transport system consisting of a track, a motor and fuel, all made from DNA. A great cartoon movie, mimicking their AFM measured observations of single-motor movements, showed the audience how a DNA motor loaded at one end of a 100-nm-long DNA track on a two-dimensional scaffold moves autonomously and at a constant average speed along the full length of the track.

Nanomedicines Design and Development

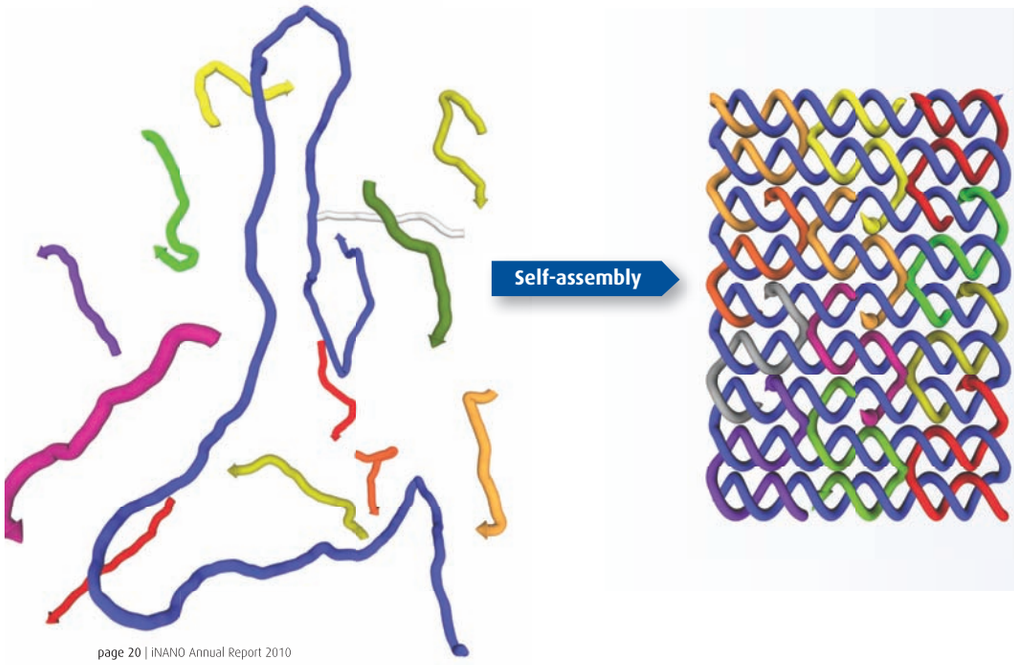
Closing the day's list of lectures, Professor Ijeoma F. Uchegbu from School of Pharmacy, University of London, shared her latest achievements in designing nanoparticles for drug delivery. Nowadays, the number of new drugs entering the market is decreasing rapidly making it difficult to develop new treatment regimes for patients. This is in part due to that many otherwise effective drugs suffer from poor delivery to the diseased site or are prevented from being used due to unfavorable biodistribution kinetics, side-effects, low solubility. Putting the drug into protective nanoparticles that are designed to travel through the body and pass the relevant barriers to delivery and unload the drug at a specific disease site is a strategy which many researchers are pursuing. In fact, some successes have been obtained for certain anti-cancer drugs loaded into liposomes, fx. Doxil. The research of Professor Ijeoma Uchegbu is focused on amphiphilic polymers with hydrophilic backbone and hydrophobic side-entities and which form polymeric micelles. This delivery system can be modulated in different aspects by changing the hydrophobic content and differentiating the use of branched and linear polymers. Using polypropylenimine dendrimer PPIG3/DNA nanoparticles Ijeoma Uchegbu has recently succeeded in demonstrating cancer-specific transgene expression mediated by systemic injection of nanoparticles. The tumor-specific gene delivery was demonstrated by whole-body nuclear imaging using small-animal nano-single-photon emission computed tomography/computer tomography scanning. The study confirmed that a tumor-selective transgene expression was obtained and that only few nanoparticles accumulated elsewhere than in the tumour. A very important achievement. "Considering that NIS imaging of transgene expression has been recently validated in humans, our data highlight the potential of these nanoparticles as a new formulation for cancer gene therapy" Igjeoma concludes.

Functionalising DNA Origami enables:

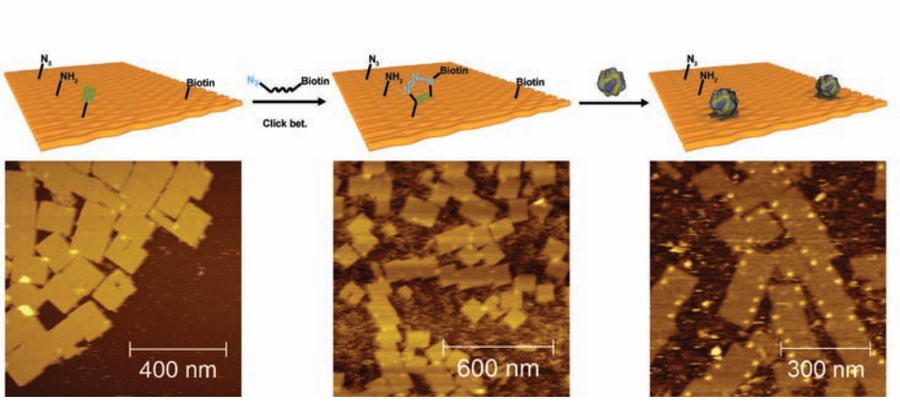
Precise chemical control at the nanoscale



Niels Vinther Voigt, Thomas Tørring and Kurt Gothelf



DNA origami formation by annealing the long template DNA strand (blue) with several short synthetic DNA strands.



DNA single strands can be designed to fold into a large two-dimensional network called a DNA Origami. A new method allows us to perform and observe chemical reactions at precise positions at the origami surface. Thereby, we can potentially attach reactive biomolecules, nanoparticles, or carbon nanotubes, to the origami at any predetermined position. This may lead to the development of sensors capable of detecting single molecules and even to nanoscale chips.

By Niels Vinther Voigt, Thomas Tørring and Kurt Gothelf

Forming billions of copies of a complex structure by self-assembly is one of the long-standing goals of nanoscience. In the recent years, DNA nanotechnology has, with the development of DNA Origami, to a large extent achieved this goal. The origami method has enabled the production of DNA structures with arbitrary shapes measuring up to 100 nanometres across.

These origami structures are beautiful and fascinating, but from a functional perspective they are somewhat dull. However, with this amazing technique at hand, the immediate next step is to expand their functionality by building-in other materials. This is possible, because one of the major advantages of the DNA Origami method is the potential to make modifications at any predetermined position. One way of doing this was demonstrated by researchers from the Centre for DNA Nanotechnology at iNANO and published in Nature Nanotechnology in 2010.

Left: *The assembled origami structures. The small chemical linker groups protruding from the surface cannot be seen by Atomic Force Microscopy (AFM).* ***Middle:*** *After a selective reaction, a biotin molecule has been attached to one of the chemical groups. However, this is still not visible in AFM.* ***Right:*** *The addition of the biotin binding protein Streptavidin is clearly visible on top of the origami.*

Linkers make the DNA Origami reactive

The DNA Origami method is named after the Japanese art of paper folding because it folds one long DNA strand into a predefined shape through the selektiv binding of approximately 200 short DNA strands. In this project we have worked with rectangles measuring 70 x 100 nanometres. In such an origami, the position of each of the 500,000 constituent atoms is known with great precision.

Our objective was to functionalise DNA Origami structures. This was achieved by attaching chemical linker groups to the small DNA strands prior to the self-assembly of the origami. As the origami folds itself by DNA hybridization these linkers are placed in predetermined positions. Next, we attached functional molecules to each linker group. The development of this new method has already allowed us to observe single chemical reactions taking place at specific positions of the DNA origami.

The research was headed by Kurt Gothelf at the Department of Chemistry in collaboration with the Scanning Probe Microscopy group and the Molecular Biology group at CDNA as well as researchers at the Heidelberg University. The major part of the work was carried out by postdoctoral scholar Alexandru Rotaru and the two PhD students Thomas Tørring and Niels Vinther Voigt at CDNA.

Chemical reactions at the right positions

The project was derived from one of our long standing goals: To assemble nanoscale electrical circuits on a DNA platform. Working towards this target, it became necessary to perform chemical reactions on DNA origami structures immobilised on surfaces. The experiments made it apparent that the origami structures were surprisingly robust since they were unaffected by multiple rounds of washings with different solvents. This inspired us to assemble a DNA Origami that displayed a variety of reactive linker groups at predefined positions and subsequently add chemical reagents to the washing solutions.

Chemical molecules themselves are too small to be observed with atomic force microscopy (AFM). Thus, to actually get a read-out of the reaction efficiency, special bifunctional reagents were synthesised. These molecules have one part that binds to the linker groups at the origami surface, while the other part binds strongly to a large protein. When this protein was added to the solution after the chemical reaction had taken place, it bound to the reagents that previously had reacted with the linkers on the origami. The attachment of the proteins could be observed by AFM and enabled us to prove that successful reactions between the linkers and the reagents had taken place. The major strength of our new method is that you know exactly where each reaction will take place and therefore you can distinguish between them with certainty. We observed that the reagents reacted with the linkers at exactly the desired positions.

Incorporating electrical wires

The ability to perform chemical reactions significantly widens the scope for applications of DNA Origami. In recent years, it has been shown that DNA Origami can be immobilised between fabricated nanoscale electrodes. Integration of organic wires, metals, or conducting polymers, in order to produce a nanochip has therefore become increasingly interesting and is one of the long-term goals that we are currently pursuing. Another interesting application is utilising the origami as a platform for studying interactions between proteins or other biomolecules at nanoscale resolution.

Caught in the act:

DNA at work

Single molecule fluorescence microscopy allows us to see individual DNA molecules in action. DNA can form complex structures such as those found in telomeres, the protein–DNA complexes at the end of chromosomes that play a key role in ageing and cancer. The movements of such complexes and of man-made DNA nanostructures can be observed as they happen.

By Victoria Birkedal

One of the most crucial questions in science is how the machinery of life works in the complex environment of the living organism. A cell is a small factory driven by specific and dynamic recognition between DNA, RNA and proteins. Nature is able to control these interactions and fold nucleic acids into astounding structures. An example is packing the two meter long double helix of the human genome into the nucleus of a ten micrometre cell.

Insight into the structure and dynamics of nucleic acids and their interaction with proteins is essential for understanding the machinery of life as well as diseases. Fortunately, detailed insight into these biomolecules can now be obtained.

Single molecule fluorescence

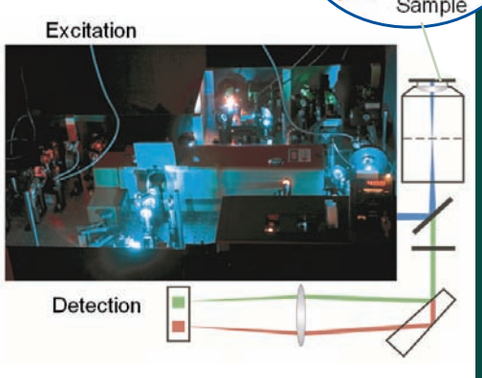
Recent – fantastic – advances in science imply that we can see and manipulate individual molecules by light in real-space and real-time. This has facilitated a paradigm shift, because studies at the single molecule level provide information on population heterogeneities unavailable with traditional ensemble studies that measure only the average properties of all the molecules in a sample. Thus, it is possible to obtain much deeper and more detailed insight into the nanoscale machinery of biological systems. These studies are also extremely well suited for exploring kinetic reaction pathways.

Our method of choice is fluorescence microscopy which allows us to visualize and study specific biomolecules individually by attaching one or several fluorescent probes along the molecule. Then, we can obtain exciting information on structure, conformational dynamics and kinetics of single biomolecules under physiologically relevant conditions.

In Aarhus, we have set up a FRET experiment that allows measurements of dynamic conformational changes on the 2-10 nm scale. Using this microscope and making further developments to the technique, we will investigate several complex natural and man-made nucleic acid structures. The project is supported by a Sapere Aude Starting Grant of DKK 8.6 millions from The Danish Council for Independent Research, Natural Sciences.

Telomeres and G-quadruplexes

One of my prime targets is telomeres, the protein-DNA complexes situated at the end of chromosomes. Telomeres play an important role in both ageing and cancer. Hence, they are being researched intensively. Telomeres get shorter with each cell division and when they are too short, the cell dies. The telomere length can be extended by the telomerase enzyme, which is active in certain cells including cancer cells. Telomere DNA is double stranded, but it terminates with a single stranded overhang that may form G-quadruplex structures.

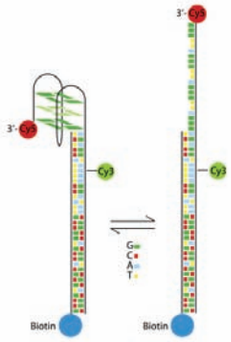


Change of colour reveals the movements of individual DNA molecules

Single molecule Fluorescence Resonant Energy Transfer (FRET) is a powerful method to study the dynamics of individual DNA molecules.

The molecules of interest are labelled with two fluorescent probes, a donor (D) and an acceptor (A). The donor is excited by laser light. If the donor is far away from the acceptor, no energy transfer to the acceptor occurs and strong donor fluorescence is detected. However, if the DNA nanostructure moves and brings the donor and the acceptor closer together, then energy is transferred to the acceptor. This results in reduced donor fluorescence and appearance of acceptor fluorescence, which means that part of the light changes from green to red.

The photo shows the Aarhus single molecule FRET microscope.



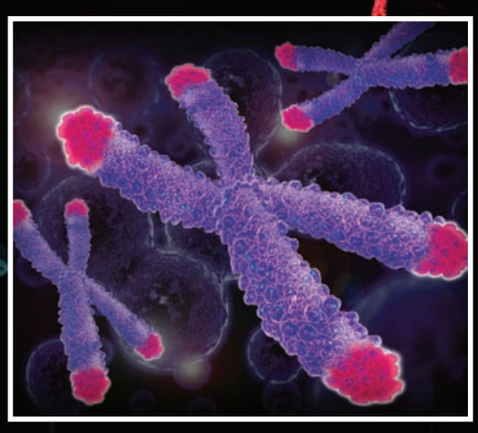
The formation of DNA G-quadruplexes at the tips of telomeres may decrease the activity of the enzyme telomerase, which is involved in most cancers. The figure shows a folded G-quadruplex to the left and an unfolded conformation to the right. The DNA structures with telomeric sequence are attached to a surface by biotin and doubly labelled with probes for FRET measurements.

Minimal constructs of G-quadruplexes have already been studied in a number of single molecule fluorescence experiments including their interactions with proteins and small molecules. These investigations revealed a large conformation diversity and interesting dynamics. Thus, the road is paved for studies of more biologically relevant structures. This may lead to a better understanding of G-quadruplex function in telomere length regulation.

Man-made DNA nanostructures on the move

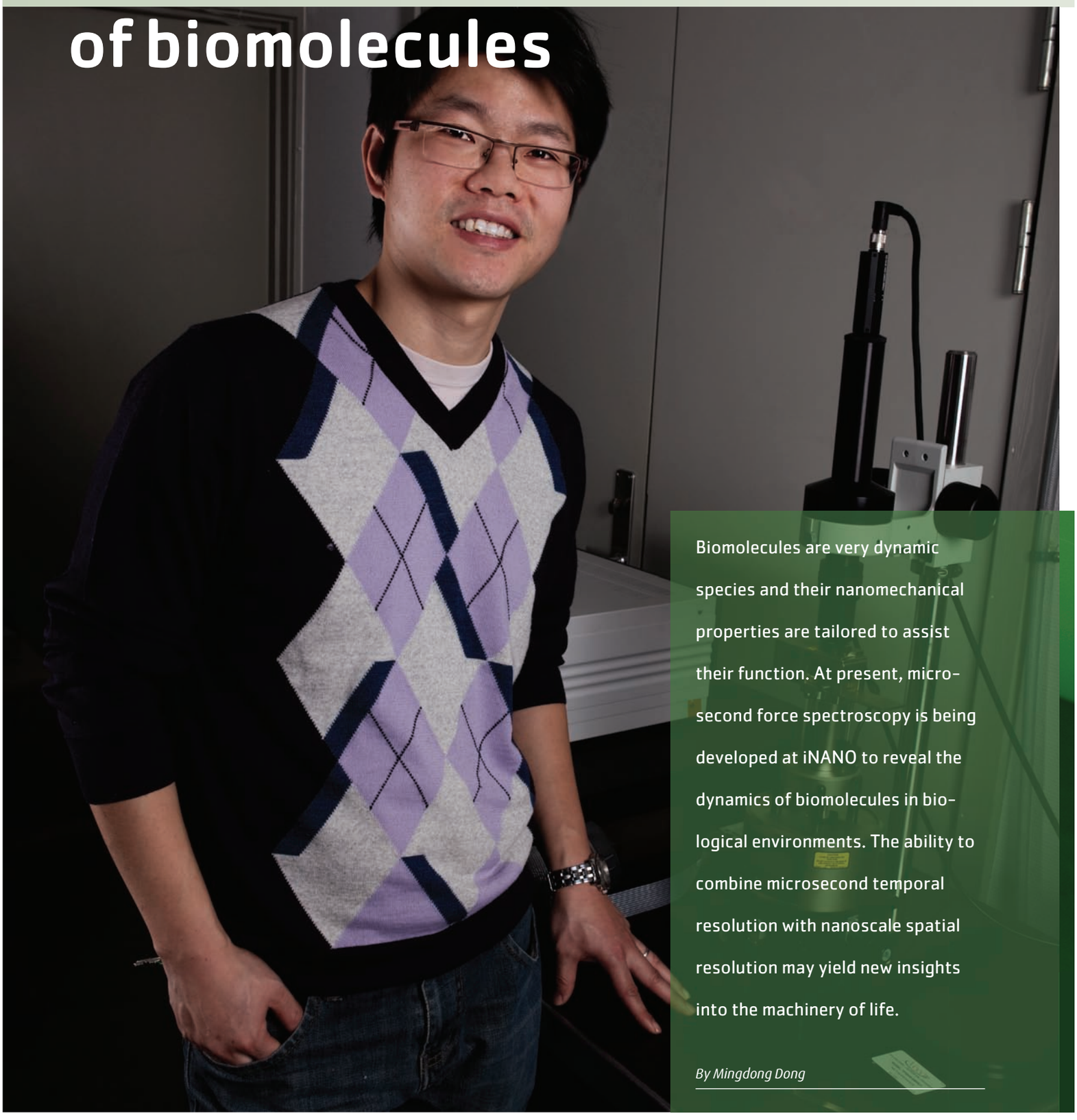
DNA nanotechnology has led to the creation of complex self-assembled nanostructures such as rods, tiles, boxes and even DNA robots being able to walk along an assembly line and pick up cargo.

One of these amazing structures is a DNA box that has been developed in Aarhus and characterized through a collaborative effort that includes my laboratory. The lid of the box can be opened and closed with DNA keys in a controlled fashion and this may lead to interesting applications such as release of drugs or signalling molecules under physiological conditions. Future single molecule FRET experiments of the opening and closing process will yield quantitative information in these naturally heterogeneous samples.



Telomeres (indicated in red in the schematic figure) are protein-DNA complexes that protect the ends of the chromosomes during cell division. They play an important role in ageing and cancer.

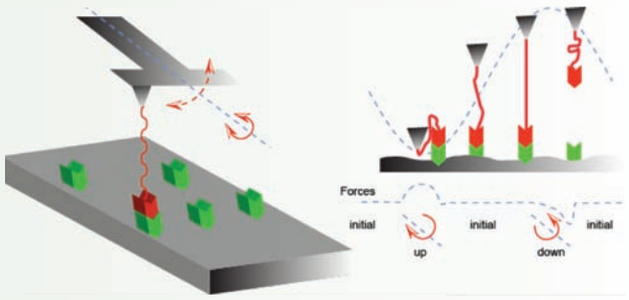
Revealing the nanomechanics of biomolecules



Biomolecules are very dynamic species and their nanomechanical properties are tailored to assist their function. At present, microsecond force spectroscopy is being developed at iNANO to reveal the dynamics of biomolecules in biological environments. The ability to combine microsecond temporal resolution with nanoscale spatial resolution may yield new insights into the machinery of life.

By Mingdong Dong

Schematic of how an interaction between a signalling molecule (red) and a biological receptor (green) can be mapped by scanning microsecond force spectroscopy. The ligand is attached to a specially designed T-shaped AFM cantilever via a flexible polymer spacer. Tip-sample interactions twist the vibrating cantilever. The vertical deflection signal gives the tip position and the twist angle gives the instantaneous force on the tip. The sharp tip vibrates in a sinusoidal trajectory (dashed blue curve). If the ligand is bound to a receptor, the flexible spacer stretches upon retraction of the tip until the ligand unbinds (solid red curve). The pulling forces drop to zero upon unbinding. The force measured before unbinding represents the strength of the receptor-ligand interaction.



The Atomic Force Microscope (AFM) is one of the foremost tools for imaging, measuring, and manipulating matters at the nanoscale. Just like a blind person gathering information on an object by feeling it with his hands, the microscope maps the nanoscale world by feeling it with a tiny cantilever tip.

In a conventional AFM microscope, the tip approaches, interacts with, and retracts from a surface, as the tip experiences attractive or repulsive forces from the surface, depending on its chemical and mechanical properties. Despite its great qualities, this method is limited in its ability to record dynamic processes due to the slow motion of the tip. However, nature is not static and high temporal resolution is required to reveal dynamic phenomena in biomolecules.

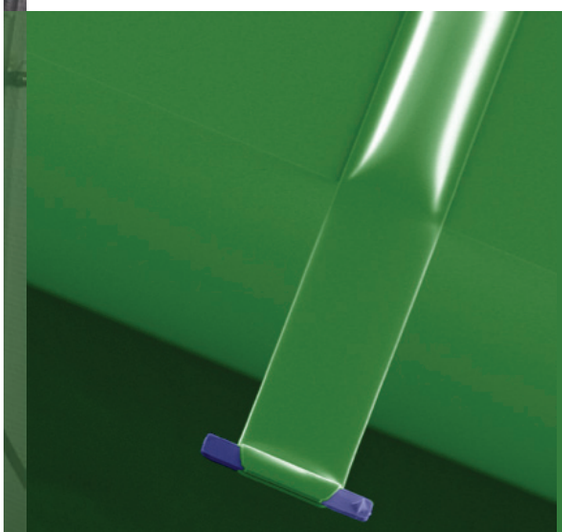
With this perspective in mind, a break-through was made by my former colleagues from Harvard University and myself, when we developed microsecond force spectroscopy. This new technique enables AFM microscopes to perform high speed force measurements with a microsecond temporal resolution. The microsecond regime is a previously unexplored timescale for mechanics in biological systems. With a Steno Grant of DKK 3 million, iNANO is now gearing up its research efforts in developing microsecond force spectroscopy and applying this novel technique to dynamic imaging and quantitative mapping of biological molecules.

High temporal and spatial resolution

An example of an important class of biomolecules is cell membrane proteins, which play a key role in all living organisms as receptors for signalling molecules as well as drugs. By conventional we mean that it is extremely challenging to study their flexibility and measure their mechanical properties. Primarily, due to the fact that when a signal molecule bind to a membrane protein or when it is activated by light, large conformational changes within the protein happen in microseconds or milliseconds. However, Microsecond force spectroscopy will, for the first time, enable mechanical studies of membrane proteins in their natural environment at the microsecond timescale by monitoring force-induced deformations across the protein structures.

Molecular interactions at a microsecond time scale

This novel technique also enables single-molecule force spectroscopy at a previously unexplored microsecond timescale. The ultrafast nanomechanical interface between a ligand attached to the tip of the T-shaped cantilever and its binding partner allows us to probe bond lifetimes approaching the limit predicted by theoretical calculations. In addition, these force measurements could be used to produce chemically specific, quantitative nanoscale images at the usual imaging speed of scanning probe techniques. Such an ultrafast nanomechanical interface will allow label-free nanoscale imaging of chemical species in biological samples.



The T-shaped cantilever with an offset tip is vibrated vertically and interacts with a biomolecule at its resonance frequency. The tip-sample interaction at the microsecond timescale can be followed through recording torsional motion of the T-shaped cantilever. Microsecond duration of the force loading enables the AFM microscope to reveal the dynamic functions of the biomolecule.

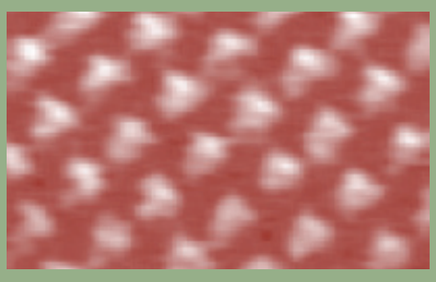
Microsecond Force Spectroscopy

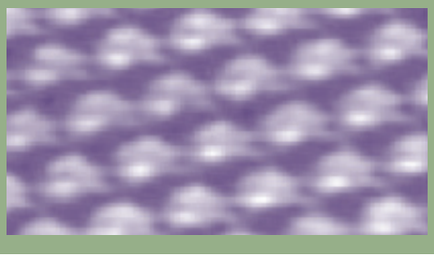
Central to the development of Microsecond Force Spectroscopy (μFS) is the creation of specially designed torsional harmonic cantilevers. These cantilevers allow varying interaction forces to be measured with microsecond temporal resolution, while material properties are determined and mapped in detail with nanoscale spatial resolution.

The tip of a torsional harmonic cantilever is offset from the axis of the cantilever. When the cantilever is vibrated vertically, tip–sample interaction forces generate a torque around the long axis of the cantilever and excite torsional vibrations. Owing to the microsecond duration of force loading, the mechanical properties derived from these waveforms will reflect molecular behaviour at the microsecond timescale.

Microsecond force spectroscopy not only provides an AFM user with the ability to simultaneously capture quantitative maps of material properties such as elasticity, adhesion force, and energy dissipation at the nanoscale, but it also allows the user to access forces and displacements with temporal resolution in the range of one microsecond.

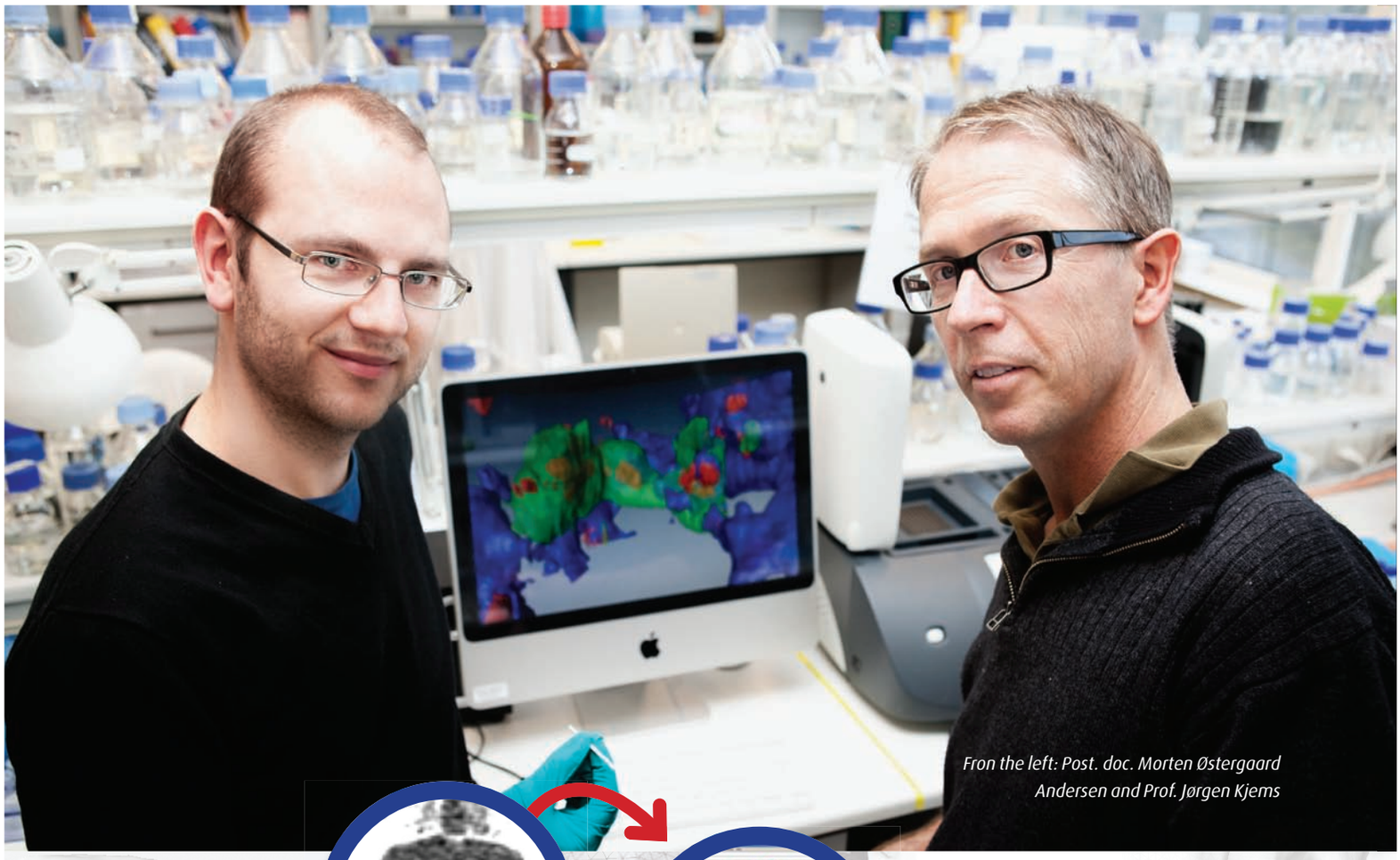
Membrane proteins play a key role in the human body as receptors for signalling molecules as well as drugs. This microsecond force spectroscopy image shows a high-resolution flexibility mapping of membrane proteins. The cytoplasmic side is shown to the top and the extracellular side to the bottom.



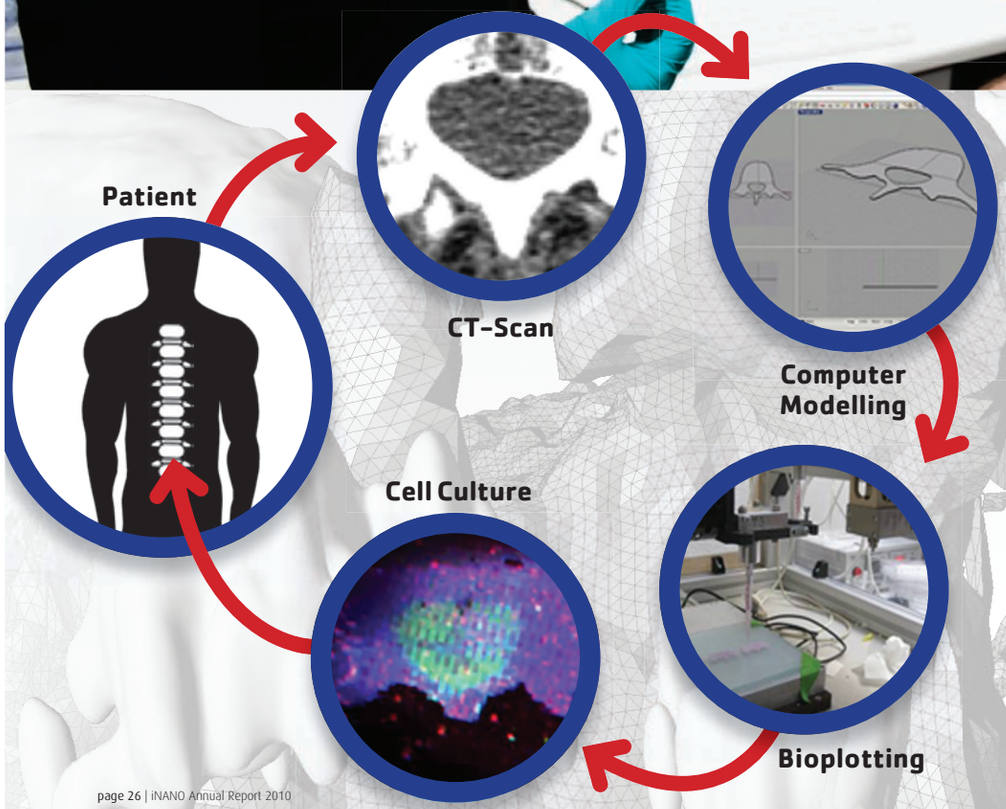


Tissue engineering at the nanoscale:

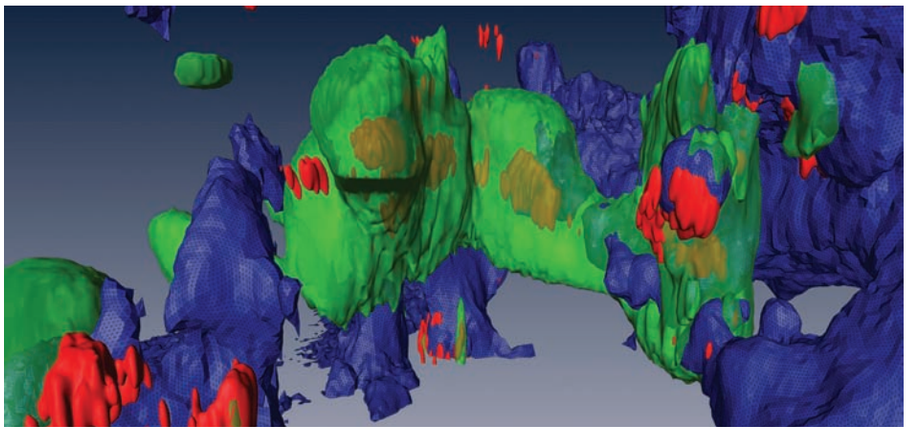
Building complex organs from stem cells



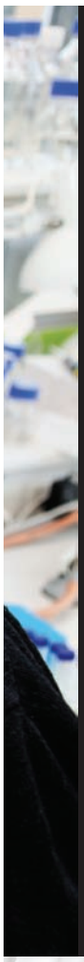
Fron the left: Post. doc. Morten Østergaard Andersen and Prof. Jørgen Kjems



Individualized tissue engineering as it is envisioned when the strategy is translated into human therapy: A patient is scanned to obtain 3D data on a defect tissue. This information is fed into a computer model where it is used to design a scaffold that fits. The scaffold model is transferred to an automated bioplotter, which prints the scaffold while it injects stem cell directing nanoparticles into pre-planned areas during the printing process. Then, the scaffold is seeded with adult stem cells from the patient, which differentiate to create the desired tissue in the correct areas according to the information provided in the siRNA. When the tissue is sufficiently developed, it can be implanted in the patient.



The picture shows a three dimensional representation of microscopy pictures. A polycaprolactone scaffold (blue) has been coated with siRNA nanoparticles (red) that can direct stem cell development. When human stem cells (green) are seeded onto the scaffold, they attach to the surface and internalize the siRNA. In turn, the siRNA directs the specialization of the stem cells.



Tissue engineering holds the prospect of producing abundant transplant organs and tissues that match the immune system of the recipient. Complex organs with multiple cell types may be built by positioning the patient's own stem cells in a scaffold. When in place, their differentiation into the required variety of specialized cells can be controlled with drug-loaded nanoparticles.

By Morten Østergaard and Jørgen Kjems

Tissue engineering is an emerging multidisciplinary field involving molecular biology, medicine, and material engineering at the nanoscale. It is likely to revolutionize our capability to improve the health of millions of people worldwide by restoring or enhancing the function of damaged tissue and organs. Simple organs like bladders, vasculature and tracheas have already been grown and tested with success in patients and in the future, organs built from a patient's own stem cells may be used to treat a wide range of diseases by offering transplantation organs and tissues that match the recipient's immune system. However, for this to take place there is an urgent need for new methods with the ability to tackle the complexity of large organs composed of several cell types.

In a collaboration between iNANO, Aarhus University Hospital and Aarhus School of Engineering we have drawn upon our multidisciplinary experience in molecular biology, material science and pharmaceutics to create a new generation of advanced implants which have recently shown promise in animal experiments. These discoveries have contributed to the launch of a Lundbeck centre in regenerative medicine, LUNA, which will provide the framework for further development of our tissue engineering systems.

Differentiating stem cells in a scaffold

The overall principle of the project is to stay as close to nature as possible. Natural tissue is composed of multiple cell types arranged in spatial geometries ordered on the micrometre and nanometre scale. To replicate this in the laboratory we started out by developing porous three-dimensional cell support structures, called scaffolds, with a microstructure and nanostructure that optimally support the attachment and growth of stem cells. In parallel, we have developed nanoparticles capable of delivering biopharmaceuticals which direct stem cell differentiation. By combining these drug containing nanoparticles with the scaffolds we have created a system capable of generating a threedimensional tissue when stem cells are added.

A favourable scaffold material is polycaprolactone, which offers several advantages. First and foremost, it is biocompatible and biodegradable. Second, it can be processed into a structure that contains both micrometre cavities for cell infiltration and nutrient diffusion and nanometer structures for adsorption of sufficient quantities of drug-loaded nanoparticles. For the drug component we use small interfering RNA (siRNA), a highly versatile type of drug capable of directing many cell processes by exploiting natural cellular control mechanisms.

Bone, fat, vasculature, and cartilage

Based on these systems we were able to steer stem cell development both in a test tube and within a mouse. More importantly, the nanostructure of the scaffolds provided spatial retention of the particles enabling us to develop different cell types in predetermined volumes of the scaffolds. The technology is a powerful platform for further research, and we are now investigating its use for building therapeutically relevant bone, fat, vasculature and cartilage tissues.

Mass production by bioplotting

However, clinical applications require mass production of highly uniform nanoparticles and scaffolds loaded with stem cells. To address this issue, we have recently turned to bioplotting technology, a strategy that enables computer controlled, automated, threedimensional depositions of stem cells, scaffold polymer and nanoparticles. A three-dimensional scan of the defect tissue provides the spatial information to a computer controling the bioplotter. An organ shaped scaffold is then printed while injecting the programmed nanoparticles at predetermined positions. After the seeding of stem cells into the scaffold, the differentiation process is carried out as dictated by the nanoparticles resulting in the desired organ. These developments in fabrication methods at iNANO will ensure individualization and reproducibility while mass production and quality control will be ensured by our collaboration with Aarhus School of Engineering.

We believe that this initiative is an unexplored opportunity to close the gap between material engineering and medicine. Moreover, we are convinced that this alliance will take the tissue engineering initiative at Aarhus University to a new and higher level needed for conducting the first clinical trials.

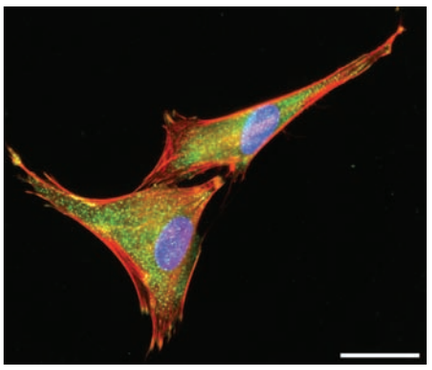
Shortening the healing period of dental implants

Left: Michael Brammer Sillassen
Middle: Ole Zoffmann Andersen
Right: Morten Foss

Two different types of titanium dental implants.

A continuously growing market for dental implants

Dental implants are used widely around the world. In 2008, the number of inserted dental implants was close to 7 million globally. Unfortunately, complications were experienced in more than 3.5 per cent of the cases. At that point in time, the global market for dental implants was estimated to have a value close to EUR 2.5 billion, and a product capable of reducing the degree of complications would be in a good position to outpace competition on this continuously growing market.



Triple stained human dental pulp stem cells. Cellular nucleus (blue), cytoskeleton (red), and focal adhesion complexes (green). The scale bar is 30 µm.

There is an increasing demand for dental implants with improved properties such as a shorter healing period and better integration into the human bone. Including strontium in the surface of titanium implants is a promising route to obtain these qualities, which could significantly reduce the risk of complications upon insertion of dental implants.

By Jørgen Bøttiger and Morten Foss

The most common cause of long-term pain and physical disability originates from bone and joint conditions. Although people of all ages may suffer from these problems, elderly people are particularly affected and as the population is ageing in many parts of the world, it has become increasingly important to develop improved and more efficient medical treatments.

A typical treatment of bone and joint conditions involves the use of a specialized medical implant. Over the last decades the performance of such implants has been improved by optimizing the medical procedures and the implant designs. Moreover, implant performance has been enhanced by modifying the surface properties including the surface topography at micro and nanoscale and tailoring the surface chemistry to guide the tissue-material interactions at the cellular and molecular level.

However, if we want to fully understand and ultimately control the extremely complex processes at the interface between artificial materials and biological tissues, it requires a truly interdisciplinary expertise from physics, chemistry, and molecular biology, bridging all the way to clinic.

Improved integration with bone

Recently, the inclusion of strontium in calcium phosphates – i.e. bone-like minerals – and ceramics has demonstrated positive effects towards bone formation in cell cultures as well as in animal experiments. Strontium is a natural trace element in the human body. It is number 38 in the periodic table of chemical elements, right beneath calcium, and thus, strontium has many of the same properties as calcium and is readily incorporated into the bone structure. Strontium is currently being used in the treatment of osteoporosis via oral delivery.

Our goal is to apply nanotechnological processes and analytic tools to gain insight into how strontium affects bone formation at molecular and cellular level. The results will be applied to optimize dental implant surfaces by strontium functionalization using an industrial-scale production platform. We expect that these novel implants will lead to a shorter healing period and a better degree of integration into the human bone structure compared to the commercial implants currently on the market.

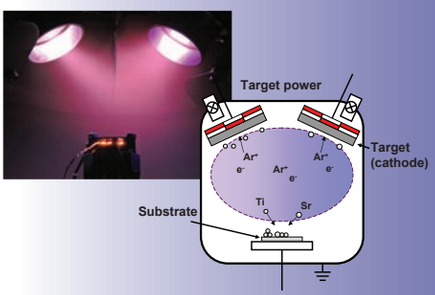
The interdisciplinary research expertise at iNANO will be combined with industrial scale processes and market knowledge in collaboration with the Danish Technological Institute and Elos Medtech Pinol A/S. The project is supported by the Danish National Advanced Technology Foundation with a EUR 1.9 million grant.

Cellular mineralisation

The initial evaluation of the cellular response to the produced surface coatings is carried out in laboratory experiments using cell cultures. The cell type chosen for the assessments is human dental pulp stem cells (hDPSCs). These are primary cells isolated at the Aarhus School of Dentistry from human third molars also known as wisdom teeth. This cell type readily mineralizes and is, therefore, well suited for determining how implant surfaces influence mineralization and hence the bone generation process. The rate of proliferation and mineralization by human dental pulp stem cells at varying strontium concentrations in titanium coatings is currently being investigated.

Pre-clinical trials

After the initial screening of the strontium containing surfaces a number of promising implant surfaces will be selected as candidates for pre-clinical trials in animals. These trials will result in detailed information on the response of the living organism to the surfaces. The next step will be to select the surface composition of the dental implants that are to be tested in humans prior to the production of the final commercial implant.



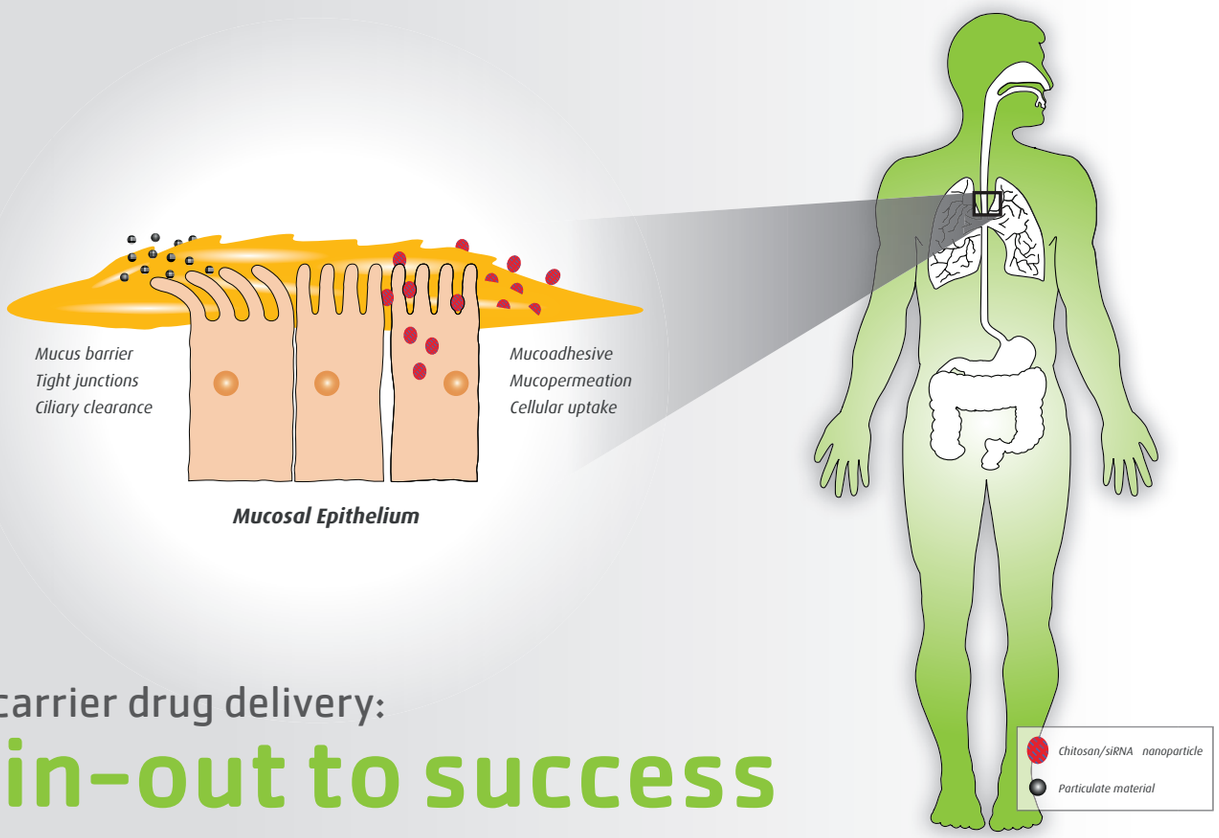
Left: Deposition with two magnetrons. Right: Schematic of magnetron co-sputtering.

Synthesis of biofunctional surfaces

Titanium-strontium surface layers are grown by magnetron co-sputtering. The surface layer is built of atoms derived from two cathodes, denoted the targets, which are composed of pure titanium and a titanium-strontium composite, respectively. These targets are biased with 400 V with respect to the substrate and placed in a vacuum chamber containing an argon plasma at a pressure of 0.0045 mbar.

Positive argon ions are accelerated towards the cathodes and when hitting the targets the energetic ions sputter off atoms of the material, which are subsequently deposited onto the substrate.

To increase the plasma intensity, magnetic field lines are placed parallel to the cathodes for electrons to spiral around. The strontium-to-titanium ratio is controlled by the powers applied to the pure titanium target and the composite strontium-titanium target.



Nanocarrier drug delivery:

Spin-out to success

The iNANO spin-out company, Nanoference, has been established to turn university discoveries into commercial products. Our aim is to provide drug delivery solutions for siRNA drugs using sugar-based nanocarrier systems. World-class science and an extensive patent portfolio have attracted interest from the pharmaceutical industry and secured seed investment for the company.

By Ken Howard

To turn an academic idea into a commercially viable product demands interplay between the inventors, University Technology Transfer, investors, and potential partners in business and industry. The iNANO spin-out company, Nanoference, was formed in May 2010 to facilitate this process with the mission to capitalize on iNANOs' intellectual property and further strengthen innovation at iNANO. Our strategy is to exploit the intellectual property surrounding the iNANO drug delivery initiative that was initiated in 2004.

Nanoference is focused on providing delivery solutions for an exciting new class of drugs called small interfering RNA (siRNA). Our technology is based on the design and development of novel sugar-based nanocarrier systems to increase the delivery and clinical potential of siRNA drugs. We use the biomaterial chitosan, derived from chitin abundant in the shells of crustaceans, to form nanocarriers that traffic siRNA cargo to the site of the disease in order to maximize the effect of the drug. Chitosan is non-toxic and used in food and cosmetics.

siRNA drugs work by gene silencing

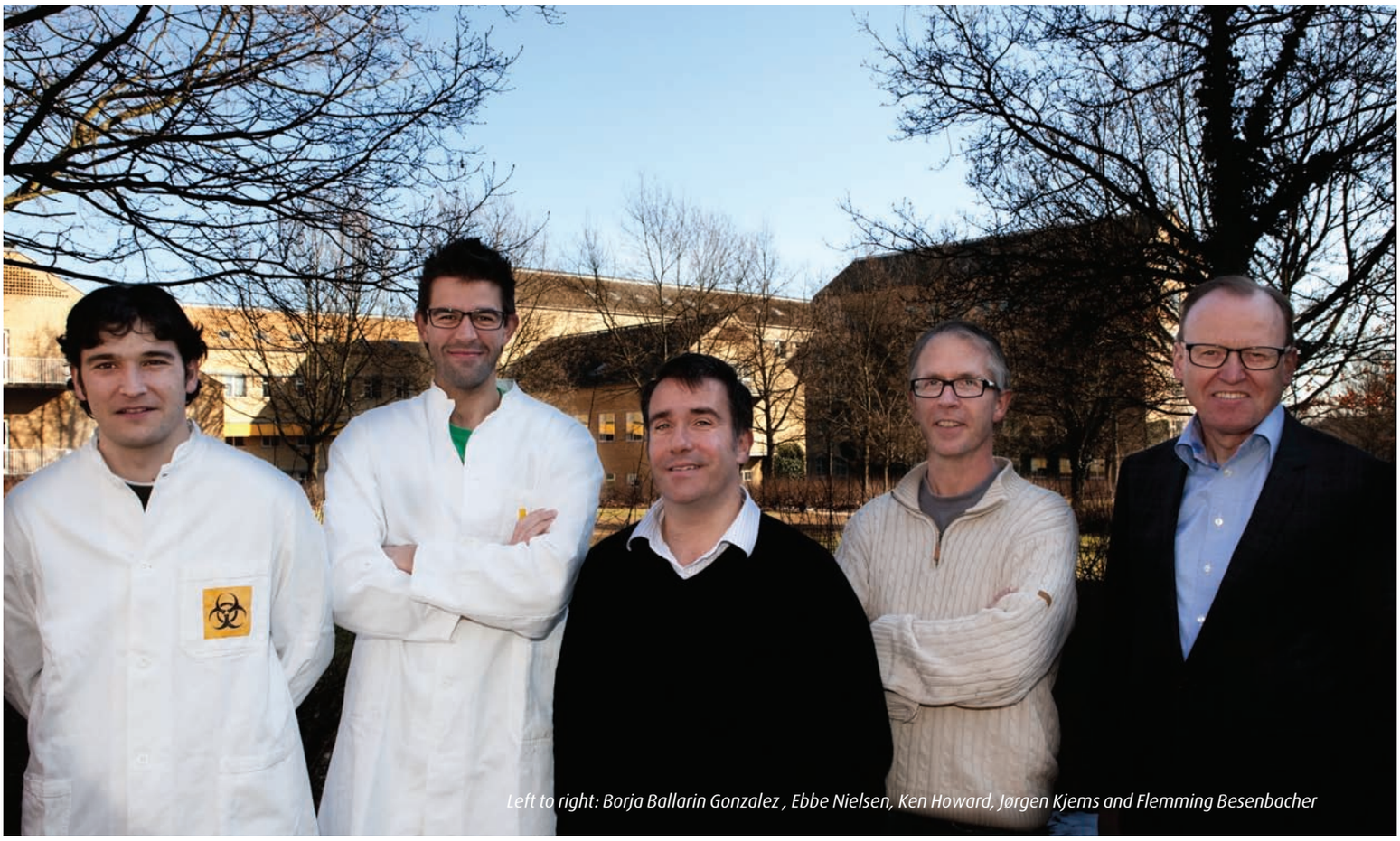
The new siRNA drugs work by silencing genes and thereby interrupting the production of their proteins. This mechanism mimics a natural process called RNA interference, which is mediated by double stranded small interfering RNA in the body. The possibility to silence genes associated with disease by siRNA drugs has led to an intense interest from the pharmaceutical industry, but unfortunately, degradation within the body and inadequate access into cells has restricted clinical development.

Shellfish material for drug delivery

Nanoferences' patented technology protects and targets siRNA by incorporation into natural chitosan-based nanocarriers. The chitosan shell protects the siRNA core and facilitates interaction with biological surfaces; especially the adhesive mucosal layers that line the respiratory and gastrointestinal tracts acting as a glue. Nasal and oral administration of the adhesive nanocarriers allow siRNA to reach these tracts and enter the target cells. Our work is focused towards applications in the treatment of infectious and inflammatory diseases such as influenza, inflammatory bowel disease, and rheumatoid arthritis.

Delivery of siRNA drugs by chitosan nanoparticles have been tested in rodents, where the treatment has showed therapeutic effects. These

NANOFERENCE



Left to right: Borja Ballarin Gonzalez , Ebbe Nielsen, Ken Howard, Jørgen Kjems and Flemming Besenbacher

proof-of-principle experiments lay the foundation for larger animal trials.

An extensive patent portfolio

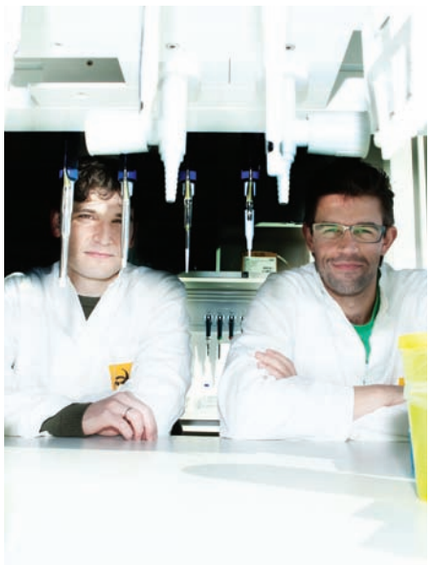
The commercial attractiveness of a University idea is reliant on securing intellectual protection. The so-called "mother patent" on the nanocarrier system was filed in 2006 followed by a series of patents surrounding the technology and its application in disease treatment.

Our portfolio now contains 5 patents, and the mother patent is now issued in Europe. This comprehensive patent portfolio reflects the innovative research being undertaken at iNANO. A license agreement between Aarhus University and Nanoference allows the company to control and maintain the patent family owned by the University.

Industrial investments

With intellectual protection secured, investment was actively sought and an engagement with Novo Seeds and SEED Capital was formed in January 2009. A process of due diligence by investors of the iNANO technology resulted in seed investment by Novo Seeds and SEED Capital in May 2010 that coincided with the launch of Nanoference. The initial investment is DKK 4.5 million over a 19 month period. This will fund the scientific activities at Nanoference and pay legal advice and consultants' fees as well as cover the costs required to maintain the patent family.

Optimal delivery of siRNA drugs is a key determinant for the clinical success of siRNA drugs and has, as a consequence, attracted much interest from Big Pharma. The aim of Nanoference is to develop the leading drug delivery solution for this novel class of drugs.



Nanoference: Versatility, vision, and world class science

The foundation for the success of Nanoference is intellectually protected, high quality ideas focused towards the needs of Industry. The technology results from the academic activities surrounding the iNANO drug delivery initiative which is a high research priority area within iNANO comprising 7 Post-docs and 11 PhD. Established in 2004, it is now internationally renowned in drug delivery research based on numerous high impact publications. These activities ensure that the spin-out company is based on world-class science.

Nanoference is based on the research activities of the co-founders: Associate professor Ken Howard, Professor Jørgen Kjems, and Professor Flemming Besenbacher. The company presently employs three scientists, Borja Ballerin Gonzalez, Ebbe Nielsen, and Shan Gao with Ken Howard as the CEO. The work is conducted within the department of Molecular Biology in a purpose built laboratory.

Artificial red blood cells as drug carriers in diabetes treatment

Interdisciplinary nanoscience

I have obtained a Sapere Aude Starting Grant of DKK 8.2 million from The Danish Council for Independent Research, Technology and Production Sciences. This allows me to build a research group able to pursue biomedical research at the highest level. Our goal is to invent and develop novel nature-inspired therapy paradigms for diabetes and other chronic diseases based on smart tailor-made delivery vehicles such as artificial mimics of red blood cells.

My background ranges over knowledge about the assembly of liposomes and gold colloids on nanostructured surfaces for biosensing applications and imaging of living cells using atomic force microscopes (AFM). The development of a novel biomedical platform termed capsosomes towards therapeutic cell mimicry was carried out during my time at the University of Melbourne in Australia. These interdisciplinary competences will allow me to pursue this ambitious project, which requires the tools of material science, chemistry, physics, nanotechnology and biology.

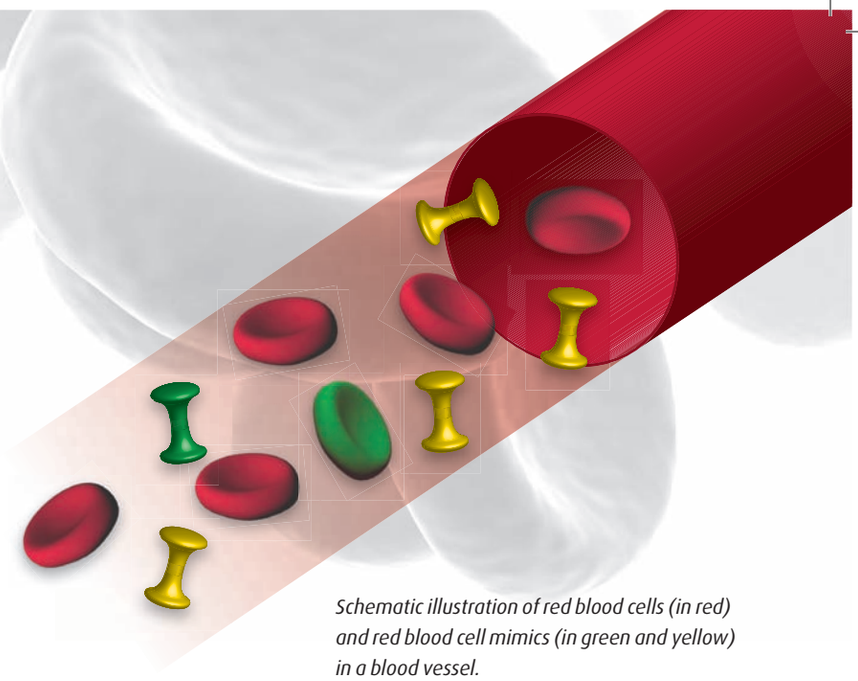
Diabetes is an exponentially increasing chronic disease affecting 285 million people worldwide. Thus, there is a great need for improved treatments. We will apply an entirely new strategy with the aim of developing tailor-made solutions for individual patients based on smart artificial cell mimics. Our first goal is to use artificial red blood cells as drug delivery vehicles.

By Brigitte Stadler

The global community faces enormous challenges with respect to provision of food, water, clean energy and housing to an expected nine billion people by 2045. Another important challenge is to develop sustainable health care for all. The developing countries badly need cheap and efficient treatments of infectious diseases, whereas the challenges in western societies are very different and mainly related to an ageing population.

This demographic trend will change our approach to health care, from simply keeping patients alive to keeping them alive while preserving or recovering their quality of life. Sustained medical care is particularly challenging when chronic diseases are involved. Though not immediately terminal, the quality of life of these patients is often considerably reduced, and the life-long treatments are costly for society.

Scanning electron microscopy image of red blood cells.



Schematic illustration of red blood cells (in red) and red blood cell mimics (in green and yellow) in a blood vessel.

An example is diabetes which affects 240,000 individuals in Denmark; a number which is believed to double within the next decade. Diabetes significantly reduces the life expectancy and is the most common cause of non-traumatic amputations and blindness in individuals under 65 years. In particular, the risk of developing various irreversible clinical complications is increased.

Prolonged circulation of drug carriers

Prolonged circulation time of drug carriers is the predominant prerequisite for the sustained drug delivery needed to treat chronic diseases and it remains one of the main challenges in drug delivery research. Current strategies often focus on miniaturization of the drug carriers while coating them with stealth polymers such as PEG to avoid instant clearing from the blood stream. However, my group intends to do something very different from this conventional approach of encapsulating drugs in nano-sized carriers. The plan for our future research involves the development of nature inspired, tailor-made solutions for individual patients based on smart artificial cell mimics.

Inspired by nature

This novel approach is called therapeutic cell mimicry due to the fact that it mimics essential parts of a biological cell or its organelles which is required for the application in mind. For instance, substituting for a missing cellular function via a sophisticated micro reactor mimicking the sub-compartmentalized structure of cells might be a powerful new concept towards enzymatic therapy. Alternatively, copying specific features of a biological cell such as the long circulation time of red blood cells could be beneficial for drug delivery applications.

Red blood cells are the most common cells in blood – we have about ten trillions of them in our bodies - and they are the main oxygen carriers. Human red blood cells are anucleated and lose their organelles during maturation. They have a size of about 7 µm and a typical biconcave shape, which provides a large surface-to-volume ratio and enhanced deformability allowing them to pass through 2-3 µm sized capillaries. Despite their large size and high number, red blood cells remain in circulation for more than 100 days before they are removed.

Red blood cells for drug delivery

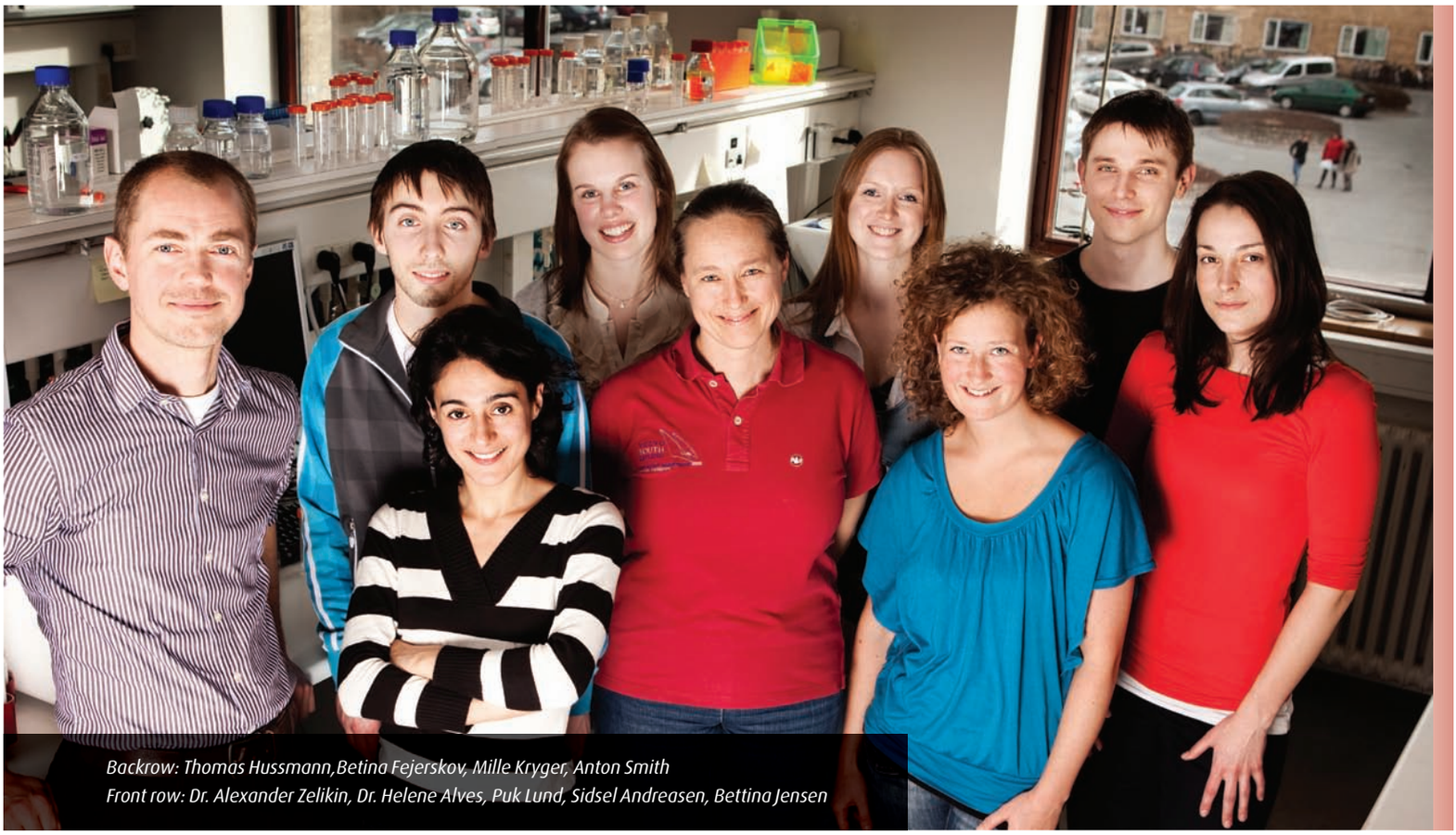
Red blood cells have been considered as drug delivery systems because of their unique properties. Unfortunately, their biological origin, issues with drug loading and the required blood type specificity are limiting factors. The collection of red blood cells also necessitates rigorous control due to the risk of transferring blood-related diseases to the recipient. Furthermore, storage is difficult.

I hypothesize that the advantages of biological red blood cells can be preserved while their disadvantages can be overcome by using synthetic mimics. Thus, this type of artificial cell will be the first model for our mimicry strategy. The main objective will be to develop and characterize highly sophisticated artificial red blood cell mimics for low invasive sustained drug delivery.

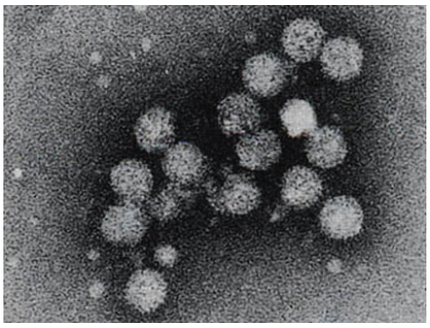
In particular, we will determine their potential as drug delivery vehicles in the context of diabetic micro-angiopathy. This is a disease where the walls of smaller blood vessels become so weak that they bleed, leak proteins and slow the blood flow, which may lead to ischemic stroke, cell death or gangrene. Artificial red blood cells may be able to deliver and release relevant therapeutics into the damaged small vessels in a sustained manner in order to stop the leakage and prevent the progress of the disease.

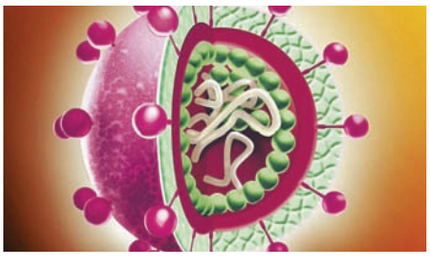
New opportunities in drug delivery to fight Hepatitis C:

Outsmarting the human defence systems and the virus



Backrow: Thomas Hussmann, Betina Fejerskov, Mille Kryger, Anton Smith
Front row: Dr. Alexander Zelikin, Dr. Helene Alves, Puk Lund, Sidsel Andreasen, Bettina Jensen





The enemy: Hepatitis C virus seen in a microscope (top). A 3D structure of the virus (bottom).

Hepatitis C virus is the cause of the most widespread viral infectious disease. Currently affecting more than 270 million people worldwide. The virus is transmitted through blood. It infects the liver and often results in chronic infections, which may lead to cirrhosis and deadly liver failure.

To date, research efforts have failed to produce effective vaccines against Hepatitis C virus and controlling the infection is the only option available for treating the patients. Unfortunately, even the most successful drugs are highly toxic and associated with severe side effects such as anaemia, headache, depression, insomnia, pain,

Medicinal Polymer Chemistry lab: Polymers for Biomedical engineering

Biomedical engineering is an interdisciplinary field wherein the successes of chemistry, physics, biology, nanotechnology and just about any other discipline are combined and used for the benefits of medicine.

For a chemist like me this implies an ability to understand the chemistry of molecules and materials so well that it becomes possible to engineer their properties and achieve favourable biomedical responses.

Within the newly established Medicinal Polymer Chemistry laboratory my team approaches biomedical challenges with a toolbox of polymer chemistry, e.g. monomer design, polymerization techniques, and supramolecular assembly of polymer chains. Our understanding of polymers is multi-angled and we are able to control both small monomers and large molecules on length scales from nanometres to macroscopic objects. Our interests and goals are diverse; from nanoscale engineering of intelligent bio-interfaces and surface medicated drug delivery to colloidal and materials science.

The next generation of drug delivery systems employed to treat Hepatitis C should aim to evade the rigorous human immune system and deliver the toxic drugs directly to the virus without harming the patient. This would improve the efficiency of the medicine and reduce the severe side effects. We hope to achieve both goals by applying the advanced toolbox of biomedical engineering.

By Alexander N. Zelikin

nausea, fever and fatigue. This is due to the fact that the medicine attacks, not only, the virus but human cells as well. Our goal is to develop methods to deliver antiviral drugs directly to the site of their action in order to achieve both a decrease in the systemic toxicity and an increased efficacy of the drug. This may lead to safer and more effective treatments that would greatly improve the life quality of patients with chronic infections.

A Sapere Aude Starting Grant of DKK 8.6 million from The Danish Council for Independent Research, Technology and Production Sciences will enable me to assemble an interdisciplinary research group with cumulative expertise in polymer chemistry, pharmacology, cell cultures and virology. We will investigate the utility of biocompatible polymers as carrier vehicles for antiviral drugs in order to accomplish targeted drug delivery, which has, so far, been elusive for the treatment of hepatitis C infections.

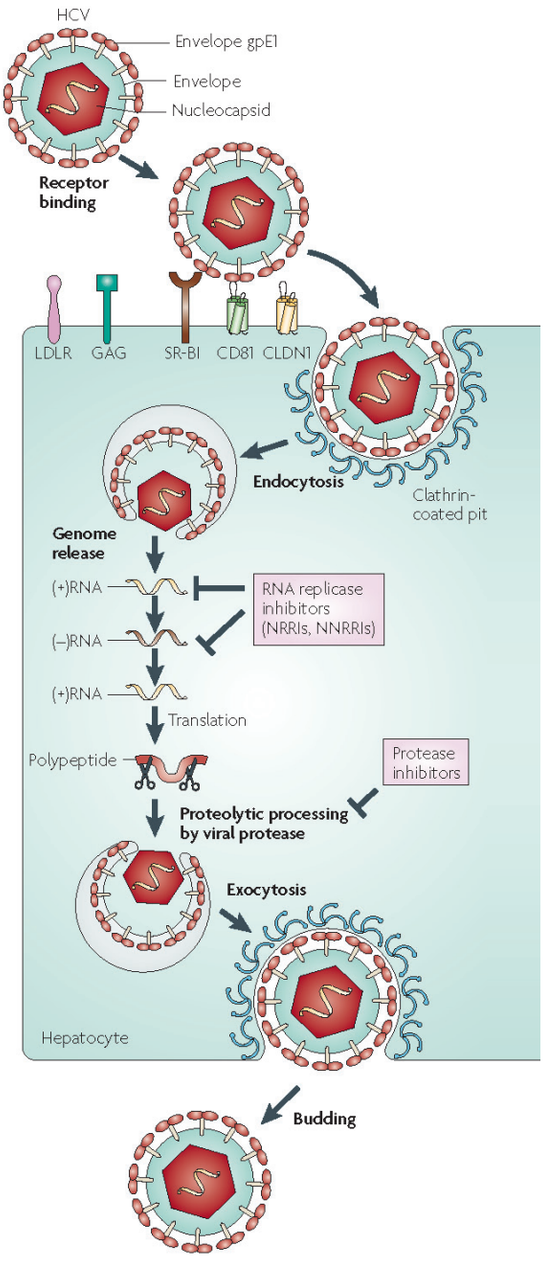
Understanding the disease

To be able to develop safer and more efficient therapies against the Hepatitis C virus we need to understand the progression of the disease and identify the best means to interfere with viral replication. Then, we need to zoom in on the mechanisms of action of the antiviral drugs to be able to engineer their release from our de novo synthesized construct, both in terms of the mechanism of release and its timing. Additionally, we will have to become knowledgeable in pharmacological properties of both the drug and the polymer carrier and utilize this knowledge in the design of the novel treatment. These individual milestones then dictate, which molecules we need to associate with which polymers and through which linkages.

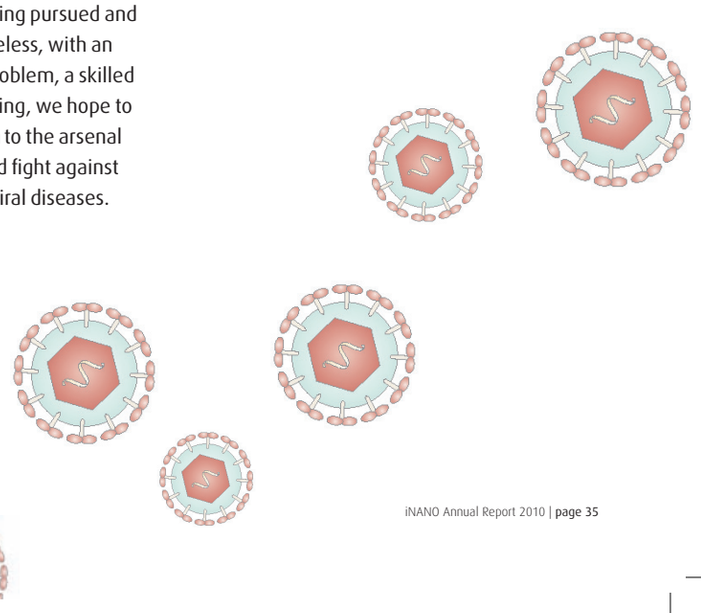
Targeting the virus

While treating a disease is never a trivial task, this particular undertaking is further complicated as we need to outsmart both the human organism and the virus. Our own natural defence mechanisms are on a constant alert and ready to eliminate foreign molecules, including drugs. Thus, a successful targeted drug delivery must overcome this natural power and transport the medicine to where it is needed. Furthermore, the virus itself will literally fight for its life and try to evade the treatment at all costs. At last, in contrast to similar approaches employed in anticancer therapy, the treatment needs to eliminate the virus, not the host cell, which often implies a narrow therapeutic window and requires precision in dosage on molecular and cellular levels.

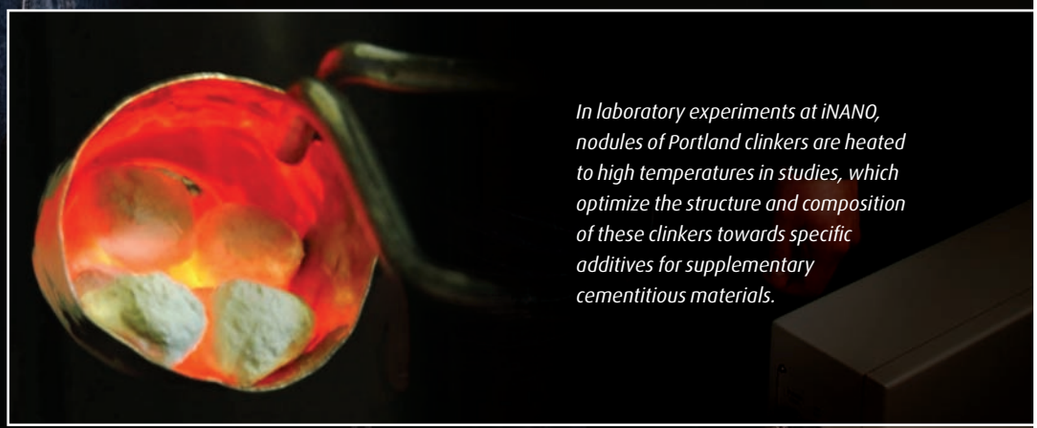
These challenges together provide an explanation as to why polymer assisted delivery of antiviral drugs is currently not being pursued and developed widespread. Nevertheless, with an in-depth understanding of the problem, a skilled team of experts, and ample funding, we hope to provide a significant contribution to the arsenal of tools available in the continued fight against Hepatitis C infections and other viral diseases.



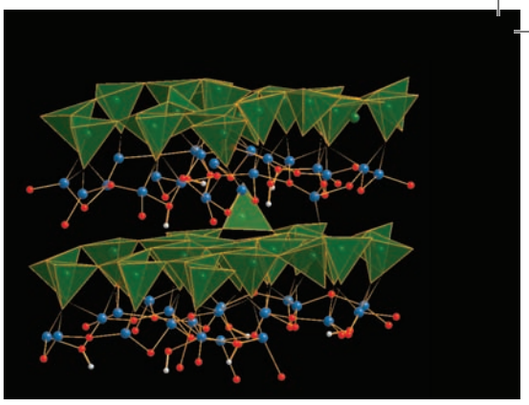
The target: New antiviral drugs should inhibit viral replication, which is shown step by step in the graphic.



Solid-state NMR experiments are extensively used in the characterization of Portland cement blended with supplementary cementitious materials. Jørgen Skibsted and Thuan T. Tran at one of the experimental setups in Aarhus.



In laboratory experiments at iNANO, nodules of Portland clinkers are heated to high temperatures in studies, which optimize the structure and composition of these clinkers towards specific additives for supplementary cementitious materials.



Proposed structure of a supplementary cementitious material obtained by dehydroxylation of a clay material by heat treatment.

New cements with low CO_2 emissions

Today, cement production accounts for about five per cent of the global anthropogenic CO_2 emissions and its share will rise as cement production is expected to double by 2050 due to the infrastructure build-up in the developing countries. New supplementary cementitious materials may significantly reduce the CO_2 emissions from the cement industry.

By Jørgen Skibsted

Concrete is the world's most durable, reliable and economical construction material with an annual consumption in volume only surpassed by that of water. Today, no alternatives for concrete can be supplied at a sufficient scale. Cement is the essential glue in concrete with an annual global production of about 2.9 billion tonnes. By 2050, experts forecast that cement production will double compared to the present, mainly as a result of the increasing need for modernisation of the infrastructure in developing countries.

Cement is made from naturally occurring minerals such as limestone, sand and clay which are heated to 1450°C in cement kilns, where the minerals chemically transform into cement clinker. This process is very energy demanding and in addition to the fuel consumption, the calcination of limestone also leads to significant CO_2 emissions. Thus, one tonne of Portland clinker is typically associated with an emission of 0.8 tonnes CO_2. On the global scale it is estimated that CO_2 emissions from the cement industry account for five per cent of the anthropogenic CO_2 emissions.

The SCM project

The SCM project is a joint collaboration between FLSmidth A/S, Aalborg Portland A/S, iNANO, Aarhus University and the Department of Energy Technology, Aalborg University. The main goal is to develop and implement novel production methods for highly reactive Supplementary Cementitious Materials (SCM's), which will result in significant reductions of the CO_2 emissions associated with cement production; the target being 30 per cent. In 2010, the Danish National Advanced Technology Foundation supported the four-year project with DKK 15 million, which equals the contribution from the partners.

Partial replacement of cement clinker

The aim of the SCM project is to achieve a significant reduction in CO_2 emissions associated with cement production. This may be obtained by a partial replacement of up to 40 per cent of the cement clinkers by new supplementary cementitious materials formed from naturally occurring raw materials such as clays.

Today, the most widely used supplementary materials - notably granulated blast furnace slag and fly ash - are industrial by-products with a limited availability that dictates the maximum degree of clinker substitution. Thus, the SCM project aims at identifying new suitable raw materials and converting them into new supplementary cementitious materials in order to obtain a further reduction in the clinker factor. Nanoscience and characterization on the nanoscale level will be utilized to develop new functionalized materials from different types of raw materials and combine these with tailor-made Portland clinkers to enable production of new cement types with reduced CO_2 emission but with the same performance and durability as today's conventional cements.

Sustainable global development

The partners aim to utilize and extend the strong and unique combination of academic and industrial expertise in Denmark to develop and implement novel production methods for highly reactive supplementary cementitious materials. A main objective is to serve the global market by developing innovative processes and corresponding know-how needed for the development of production equipment which is able to convert locally available raw materials into high-quality cement products. Another goal is to optimize the local cement production at any given site to achieve the highest possible CO_2 reduction by utilizing these new supplementary cementitious materials.

A positive outcome of the project will position Danish industry at the forefront with respect to climate-friendly cement products based on supplementary cementitious materials. Wide-spread use of such products will significantly contribute to a sustainable global development.

Industrial market leaders

Increasing energy costs and requirements for emission reductions are posing new technical challenges to the cement industry. A breakthrough in the production of new supplementary cementitious materials will offer an opportunity to raise the industrial standards by utilizing strong university competences to create a technological knowledge base from which FLSmidth can subsequently develop advanced process equipment for the manufacturing of supplementary cementitious materials. This will contribute to making FLSmidth a market leader within SCM-production technology worldwide.

Furthermore, Aalborg Portland's production of cement will serve as a case study. Indeed, the overall idea of the project is to utilize this new technology in full-scale production of high-quality cements with high contents of supplementary cementitious materials and low embodied CO_2 emissions. This will strengthen the competitive position of Aalborg Portland, who is a major supplier of grey cement to the Scandinavian market and a world market leader in white cement.

Cities are well suited for solar panels. Power is produced where people need it and no arable land is used.

Internal reflections of sunlight may boost the efficiency of cheap solar cells

Thin-film nanocrystalline solar cells with backside reflectors that enable internal reflections of sunlight could substantially increase solar cell efficiency. Such cells may be produced from low-cost materials and thus deliver sustainable electricity at a price that is competitive with power from fossil fuels.

By Brian Bech Nielsen, Arne Nylandsted Larsen, Thomas Garm Pedersen and Kjeld Pedersen

By the end of this century, the annual global power consumption is expected to be 50 TW, which is four times greater than current consumption. Although other types of renewable energy sources already contribute significantly to the global power production and will continue to do so, neglect of the significance of solar power can only be described as "avoiding the obvious". Sunlight deposits an enormous amount of energy – about 120,000 TW - on the Earth's surface. Hence, solar energy has the potential to become a limitless and sustainable source of electricity.

Today, commercial solar cells made from crystalline silicon typically convert 15 per cent of the solar energy into electricity. Using such cells the area required to meet the demand in 2100 would be about the size of Mexico, but fortunately this large area can be covered by utilizing urbanized and dessert-like regions of little or no agricultural value. Nevertheless, to fully exploit the vast potential of solar power, the next generation of solar cells must be cheaper and more efficient.

In the THINC project we will conduct a coordinated, experimental and theoretical research effort in order to achieve both goals and by using a completely new design: We propose a solar-cell structure based on a thin film of nanocrystalline silicon grown on top of a high-refractive material. Efficient light harvesting will be achieved by a specialised back reflector, which reflects unused photons back into the electricity producing layer. Moreover, we will also deposit cells on flexible substrates. This may pave the way for a range of new applications - not least in modern architecture - and for manufacturing the cells in a reel-to-reel process. An alternative route, where the silicone backing is replaced by a structured but non-flexible substrate or by a planar substrate such as silicon, will also be explored.

The THINC project

The THINC project is financed by the Danish Council for Strategic Research through a five-year grant of DKK 18.9 million. THINC is a collaboration between Department of Physics and Astronomy, Aarhus University, Department of Physics and Nanotechnology, Aalborg University, iNANO, and Polyteknik A/S with CNR-IMM Bologna and I3N-University of Aveiro as partners.

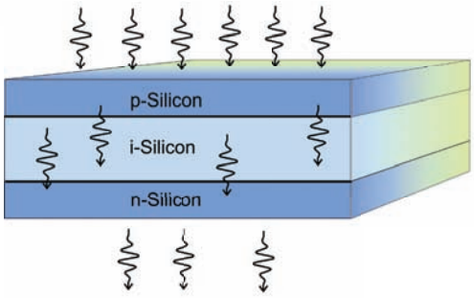
As cheap as fossil fuels

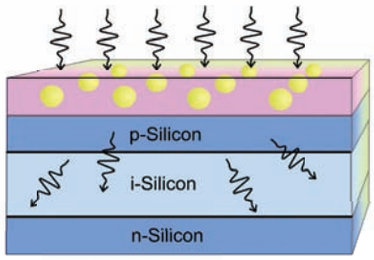
The expected results of the THINC project can be divided into two categories. Firstly, the proposed solar cell structure may achieve a conversion efficiency, which is high enough to compete with fossil fuel technologies. The basic design is relatively simple, and only low-cost materials are involved; we therefore expect that the solar cells can be produced cheaply at an industrial scale. Moreover, the possibility of producing solar cells on a flexible substrate may create a niche market for Danish industry. In this context, it should be noted that the industrial partner in this project has previous expertise on how to deposit thin films on a flexible silicone sheet in a roll-to-roll process.

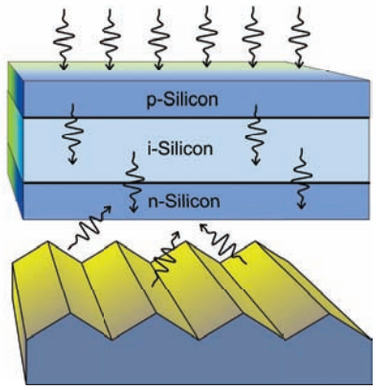
Secondly, we will gain a substantial knowledge on the properties and synthesis of new nanomaterials and on how to simulate the electrical and optical properties of the resulting structures. In other words, we will advance our understanding of processes of vital importance for a substantial part of the future's sustainable energy technology.

Prof. Brian Bech Nielsen

Prof. Arne Nylandsted Larsen







Highly efficient thin film solar cells

The illustration shows our concepts for increasing the absorption of sunlight in thin-film solar cells. In a conventional design (a), a large portion of the sun light, especially the long wavelength part, escapes absorption and passes right through the structure. By including scattering nanoparticles (b), light is redirected into oblique angles and thereby the chance of absorption increases. Under the right conditions the light can even remain trapped inside the structure until it is eventually absorbed. Alternatively, adding a structured rear reflector (c) redirects transmitted light back into the solar cell leading to increased absorption. In THINC, the two strategies (b) and (c) will be exploited and optimized, both individually as well as in combination.

In the proposed flexible solar-cell, the SiO_2 layer on top acts as an anti-reflection coating. Thus, the light will penetrate the device and enter the thin silicon layers measuring 1-10 µm across in the middle of the device. The intrinsic layer (i-Si) consists of nanocrystalline silicon, which strongly absorbs incoming short-wavelength photons and converts their energy into pairs of holes and electrons, which are separated by the internal electric field created by the surrounding layers (p-Si and n-Si), and used for electricity generation.

The remaining photons propagate to the silver layer at the bottom of the solar cell that reflects them like a mirror. The triangular structures in the silicone substrate will be fabricated in such a way that the reflected rays are deflected by about 35°-45° away from the line of incidence in order to secure maximum light harvesting.

The dominating part of the reflected light enters back into the p-i-n layer where it will be completely internally reflected at the p-Si/SiO_2 interface. Thus, the light will pass through the p-i-n structure several times, which will substantially increase the solar-cell efficiency.


Prof. Kjeld Pedersen


Prof. Thomas Garm Pedersen

iNANO and industry

Message from the Chairman

It is my pleasure to write my first message for the iNANO Annual Report after I was elected chairman of the iNANO Board in January 2010. I am only the second chairman and I would like to take this opportunity to thank the first chairman, Hans Jørgen Pedersen, for his service and dedication to iNANO since its inauguration in 2002. Under his reign, I have seen first-hand how iNANO has flourished and achieved international renown. Today, iNANO serves as a role model for interdisciplinary research centers, not least because of the efforts made to carry out industrially relevant research and to set up a successful study line in nanoscience.

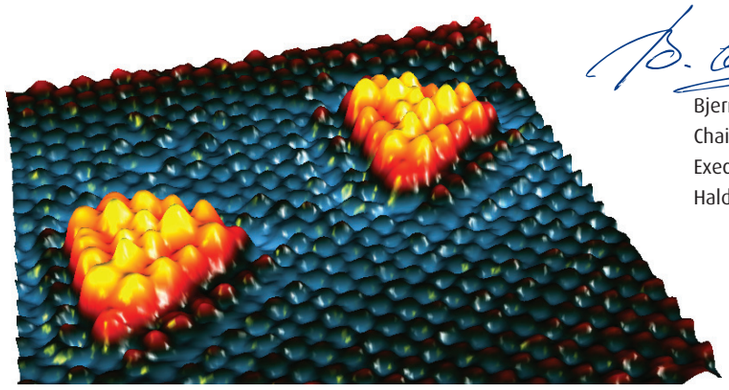
For many years, I have had strong ties to iNANO through my workplace, catalyst and technology company, Haldor Topsøe, which has benefited immensely from a fruitful collaboration with iNANO. This has given us unprecedented insight into the atomic details of many of the catalysts offered by Topsøe to the global market. In fact, these studies have enabled us to develop new and better catalysts improving our market share.

At iNANO, I have been met with a strong dedication to tackle the real problems that exist in industry and my impression is that the researchers are excited to experience that their work is useful and wanted outside of academia. I can only encourage other scientists to engage themselves in this kind of mutual interaction with industrial laboratories, not only motivated by personal aspirations but also because it is a way to make a real difference. I also see this kind of dedication in iNANO's efforts to develop and execute a successful interdisciplinary education in nanoscience. I know from personal experience that from the very beginning, the requirements and needs of high-tech industries were taken into account when defining the nanoscience curriculum and I am happy to see that many of the graduates are taking up positions in industry.

Another aspect of iNANO's strong dedication to aid the development of the society is the emergence of spin-out companies. With the new iNANO house to be inaugurated in 2012, the possibilities to spin-out and host new companies will be even stronger and will ensure a close coupling to excellent research environments.

I look very much forward to continuing to work with the iNANO organization in future years.

Bjerne Clausen
Chairman of the iNANO board
Executive Vice President, Technology Division,
Haldor Topsoe A/S

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Tracking changes at the surface
oticon
PEOPLE FIRST
ALFA LAVAL
AstraZeneca
UNITED KINGDOM
Elkem
Danfoss
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Highlights 2010

A testimony of the large recognition that iNANO scientists receive from their peers and the society is evident from the many awards and appointments they receive each year

iNANO researcher receives "Sapere Aude" Young Elite Research grant

In 2010, postdoc Alireza Dolatshahi-Pirouz received 3.9 million kroner to fund his upcoming research project entitled, Micro- and nano-engineering approaches to generate a high throughput platform for screening stem cell fate. Alireza Dolatshahi-Pirouz graduated from the iNANO School in 2009. The upcoming project will take place at Harvard-MIT in collaboration with prof. A. Khademhosseini.

Carlsberg memorial scholarships to iNANO researchers

Louis Nilsson (iNANO) and Mathias Juul Jacobsen (iNANO and CDNA) have each been awarded a scholarship valued at DKK 75,000 in memory of the brewer J. C. Jacobsen. Louis Nilsson is studying for an Honours Master's degree (PhD) at the Interdisciplinary Nanoscience Center (iNANO) under the supervision of Associate Professor Liv Hornekær. Louis Nilsson will use his scholarship for a study period at Xue's laboratory in Beijing, China. This is one of the absolute leading laboratories in the world for scanning tunnelling microscopy at low temperatures combined with strong magnetic fields. Mathias Juul Jacobsen is working on his Master's degree project at the Centre for DNA Nanotechnology (cDNA), where he is involved in the synthesis of artificial DNA bases that can selectively go in and block a specific DNA base. After graduation, he will be moving to Switzerland, where he has been awarded a PhD fellowship at the Swiss Federal Institute of Technology (ETH) Zurich.

Professor Flemming Besenbacher appointed Honorary Professor at two leading Chinese universities

Professor Flemming Besenbacher, Aarhus University, Denmark, has been appointed Honorary Professor at two leading Chinese universities, Chongqing University in Central China and Tongji University in Shanghai, for his contributions to word-leading research and research management. Prof. Besenbacher has been instrumental in promoting a national strategy for Sino-Danish scientific collaborations. During the past decade, Prof. Besenbacher has given numerous guest lectures to advance the quality of education and research at several Chinese universities and research institutes.

iNANO scientist elected for the Dragon 100 Young Chinese Leaders Forum

In 2010, Dr. Mingdong Dong, iNANO, was elected to participate in the Dragon 100 Young Chinese Leaders Forum. The Dragon 100 annual programme was first launched in 2002 and brings together 100 youth leaders of Chinese origin from around the world every year. During the programme which included academic seminars, the delegates meet government officials, academics and professionals; visited the World Expo and major socio-economic and cultural development projects.

Scientist from iNANO honoured in entrepreneurship competition

This year's Life Science & Medtech category of the annual Venture Cup was won by an interdisciplinary group led by iNANO scientist, Morten Foss. The team was rewarded with DKK 50,000 for a business plan involving fabricating cell culture wells which enable growth of different specific cell types such as human stem cells. The basic IPR behind this business plan was generated by an interdisciplinary team from iNANO. The business plan was developed by Morten Foss from iNANO in collaboration with Theodor Nielsen from Nil Technology. Venture Cup is an annual competition which strives to inspire and motivate entrepreneurship and turn academic knowledge into viable high-growth businesses. This is done by exposing the participants to a network of experienced entrepreneurs and business people and is supported by the Danish universities.

Professor Allan S. Hoffman Honorary Professor at the Faculty of Science

The dean of the Faculty of Science has appointed professor Allan S. Hoffman, University of Washington, Seattle, WA, USA, as honorary professor at the Faculty of Science. Allan S. Hoffman, professor of bioengineering and chemical engineering, University of Washington, Seattle, WA, has for a long time been one of the world-leading scientists with numerous experimental studies in the application of polymers in medicine in particular over the past 55 years. Over the past 4 years, Allan has been a very active and outstanding guest professor with many visits to the Interdisciplinary Nanoscience Center (iNANO), Aarhus University, and he has given very inspiring lectures on drug delivery and protein interactions with nanostructured surfaces. His extensive knowledge within the fields of polymer chemistry, drug delivery and

Crown princess Mary and Professor Kurt Gothelf at the EliteForsk award ceremony

protein-surface interactions and connections with world-renowned scientists will once again prove to be a valuable addition to both research and teaching activities at iNANO.

Director of national Chinese nanocentre Adjunct Professor at the Faculty of Science

The dean of the Faculty of Science has appointed prof. Chen Wang, director of the National Centre for Nanoscience and Technology (NCNST), Beijing, as Adjunct Professor at the Faculty of Science. The NCNST is a Chinese Academy of Sciences institute and is thus to be considered the top nanocentre in China. Professor Chen Wang is a truly outstanding scientist. Prof. Chen Wang has for a long time been one of the world-leading scientists in the area of nanoscience and nanotechnology, and he and his group have made excellent and unique contributions on the applications of scanning probe microscopy in surface characterizations and fabrications. In particular he revealed several novel effects in molecular self-assembly. Over the past 5 years Prof. Chen Wang has been very active in establishing a solid collaboration between the NCNST and iNANO. He paid many visits to Aarhus University where he has given very inspiring lectures on molecular self-assembly on surfaces. Chen Wang's commitment to the Faculty of Science and iNANO will be strengthened further by Chen Wang's appointment as Adjunct Professor at the Faculty of Science.

Professor Poul Nissen receives the Rigmor and Carl Holst-Knudsen Award

In May 2010 Professor Poul Nissen was awarded the Rigmor and Carl Holst-Knudsen Award for Scientific Research. Professor Poul Nissen receives the award for his ground-breaking cell research with therapeutic potential. 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.

Philip Hofmann appointed Professor with Special Responsibilities

Philip Hofmann was in March 2010 appointed Professor with special responsibilities in experimental physics at the Department of Physics and Astronomy, the Institute for Storage Ring Facilities and iNANO. Philip Hofmann was born in Berlin in 1967. He studied physics at the Free University, Berlin, and did his PhD research at the Fritz-Haber-Institute of the Max Planck Society, also in Berlin. He stayed at the Oak Ridge National Laboratory, USA, as a Feodor Lynen Fellow of the Alexander von Humboldt Foundation. In 1998, he moved to Aarhus where he has been employed at the Institute for Storage Ring Facilities (ISA), Aarhus University. His research is primarily focused on the electronic structure of solids and their surfaces.

iNANO PhD student wins best oral presentation award

April 2010, PhD student Kristian Kolind won the price for best oral presentation at the Scandinavian Society for Biomaterials meeting in Hafjell, Norway. Kristian's research is on creating micro- and nano-scale functionalized 2D surfaces and 3D scaffolds acting as advanced bioactive materials for guided expansion and differentiation of specifically targeted human cell types relevant for cell replacement therapies and regenerative medicine. The title of his presentation in Norway was: "A combinatorial approach to systematically screen for the microtopography induced changes in proliferation, focal adhesions and cytoskeletal organization"

Professor Kurt Gothelf receives the EliteForsk award

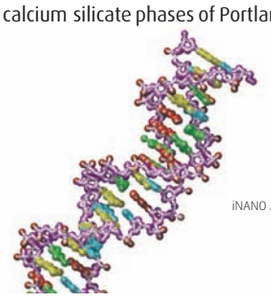
In January 2010 one of five annual EliteForsk (elite researcher) awards was given to professor Kurt Vestager Gothelf, iNANO researcher and director the of affiliated cDNA center. The prize consists of 1 mio. DKK for research activities and 0,2 mio. as a personal award.

Kasper Jahn from iNANO and CDNA wins Rock'n Research

This year's Researchers Grand Prix (nicknamed Rock'n Research) held in Lille Vega was won by Kasper Jahn, PhD student at iNANO and cDNA. Eight PhD students, one from each of the Danish universities, competed in the art of communicating their research to 100 high school students in just 3 short minutes. Kasper presented his studies on the use of DNA origami to produce extraordinary structures that may eventually be used in the combat of cancer.

iNANO PhD student wins prize for best oral presentation

PhD student Thuan T. Tran of iNANO and the Department of Chemistry won the prize for the best oral presentation given by a PhD student at The 31th Annual Danish NMR Meeting. Thuan T. Tran's research is associated with the project "FUTURECEM", - a collaboration between iNANO, Aalborg Portland A/S, and GEUSCopenhagen, partially funded by the Danish National Advanced Technology Foundation.
The title of his presentation was: "Structural investigations of guest-ion incorporation in the calcium silicate phases of Portland cement by 19F,



Publications

A complete list of iNANO publications and specialized lectures can be found at our homepage.

Publications 2010:
http://inano.au.dk/research/publications/2010/

Specialized lectures 2010
http://inano.au.dk/news-events/specialized-inano-lectures/2010/

iNANO lectures 2010

January 15, Professor and Head of Molecular Oncology Jan Mollenhauer, Medical Biotechnology Center, University of Southern Denmark, Odense, Denmark, "Nanomedicine for cancer stem cell targeting: Strategies and tools"

January 22, Professor and Director J. K. Nørskov, Center for Atomic-scale Materials Design, Department of Physics, Technical University of Denmark, Kgs. Lyngby, Denmark, "Catalysis for sustainable energy"

January 29, Professor Martyn Poliakoff, CBE FRS, School of Chemistry, Nottingham University, Nottingham, England, "Green Catalysis in Supercritical Fluids"

February 5, Assistant Professor Alexander Zelikin, Department of Chemistry and Interdisciplinary Nanoscience Center, Aarhus University, Aarhus, Denmark, "Polymer hydrogel capsules: "Exotic" drug carriers proven unique"

February 12, Professor Herman Autrup, School of Public Health, Aarhus University, Aarhus, Denmark, "Safety of nanoparticles – Biological effects of AgNP"

February 19, Associate Professor Birgitta R. Knudsen, Department of Molecular Biology, Aarhus University, Aarhus, Denmark, "Nano-Scale 3D DNA Cages: Structural and functional properties and their applications"

February 26, Director Claude R. Henry, Interdisciplinary Nanoscience Center of Marseille (CINaM-CNRS), Marseille, France, "Regular arrays of mono and bi-metallic clusters: almost perfect planar model catalysts"

March 5, Professor Reshef Tenne, Department of Materials and Interfaces, Weizmann Institute, Rehovot, Israel, "Inorganic nanotubes (INT) and fullerene-like structures (IF)"

March 8, Professor Anthony Watts, Biomembrane Structure Unit, Biochemistry Department, Oxford University, Oxford, UK, "Ligand dynamics and structure in membranes resolved at the nanoscale" Joint Chemistry and iNANO Lecture

March 9, Director Leonard C. Feldman, Institute for Advanced Materials, Devices, and Nanotechnology, Rutgers University & Institute for Nanoscale Science and Engineering, Vanderbilt Universtity, New Jersey, US, "The materials revolution" iNANO and General Physics Lecture

March 10, Associate Professor Erik Wahlström, Department of Physics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway "Towards a fundamental understanding of size effects in LSMO" Joint ISA and iNANO Specialized Lecture

March 12, Professor Dr. Jochen Feldmann, Photonics and Optoelectronics Group, Ludwig-Maximilians-University, Munich, Germany, "Nanoplasmonics and biomolecules"

March 19, Associate Professor Ken Howard, Interdisciplinary Nanoscience Center, Faculty of Science, Aarhus University, Aarhus, Denmark, "Drug delivery in an interdisciplinary setting"

March 26, Professor Dr. Hans Wolfgang Spiess, Max-Planck-Institute for Polymer Research, Mainz, Germany, "Nanostructured functional materials: A challenge for structural and dynamic characterization"

April 9, Director Terry McMaster, H. H. Wills Physics Laboratory and Bristol Centre for Functional Nanomaterials (BCFN), University of Bristol, Bristol, UK, "Force recognition localization of specific protein and glycoprotein moieties using atomic force microscopy: interdisciplinary nanoscience research in Bristol"

April 28, Professor, Doctor Joachim P. Spatz, Max-Planck-Institute for Metals Research, Department of New Materials and Biosystems, Stuttgart & University of Heidelberg, Department of Biophysical Chemistry, Heidelberg, Germany, "Regulation of cellular responses on the nanometer scale"

May 7, Doctor Cyril Aymonier, Institut de Chimie de la Matière condensée de Bordeaux, CNRS – Université de Bordeaux, Bordeaux, France, "Design of advanced nanostructured material using supercritical fluids"

May 21, Professor and Head of Division Søren Linderoth, Fuel Cells and Solid State Chemistry Division, Risø DTU, Denmark, "Solid oxide fuels cells: Nanostructures in play"

May 28, Research Leader Lyubov Belova, Engineering Material Physics, Royal Institute of Technology, Stockholm, Sweden, "Nanotechnology: Does it have to be complicated?"

June 4, Professor Rasmita Raval, Department of Chemistry, University of Liverpool, Liverpool, UK, "Molecular Assembly at Surfaces: Chirality from the nanoscale to the macroscale"

June 11, Professor Doctor Boris N. Chichkov, Head of Nanotechnology Department, Laser Zentrum

Hannover e. V. Hannover, Germany, "Laser-based nanotechnologies for applications in photonics and biomedicine"

June 18, Professor Doctor Helmut Dosch, Chair of the board of directors, Deutsches Elektronen Synchrotron (DESY), Hamburg, Germany, "Order, disorder, ice, water: Unknowns and mysterious things"

June 25, Assistant Professor Lene Niemann Nejsum, Department of Molecular Biology, Aarhus University, Aarhus, Denmark, "Cell polarization: initiation and maintenance"

August 6, Director, professor Chen Wang, National Center for Nanoscience and Technology, Beijing, China, "SelfÐassembled twoÐdimensional organic and peptide molecular architectures observed by using scanning tunneling microscopy"

August 13, Director Sonia Contera Institute of Nanoscience for Medicine, Oxford University, Oxford, UK, "High resolution dynamics and mechanics of biological systems with AFM: From single molecules to living cells and nanomedicine"

August 20, Professor Dr. Torsten Linker, Department of Organic Chemistry, Potsdam University, Potsdam, Germany, "Selective reactions of singlet oxygen: From synthesis to photolithography and molecular motors"

September 3, Dr. Gerd Leuchs, Max Planck Institute for the Science of Light & The University of Enlangen-Nürnberg, Enlagen, Germany, "Coupling light to nanostructures"

September 10, Associate Professor Liv Hornekær, Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark, "Graphene: how to control its electronic properties"

September 17, Assistant Professor Björn Sander, Stereology and Electron Microscopy Laboratory, Institute of Clinical Medicine, Faculty of Health Sciences, Aarhus University, Aarhus, Denmark, "Electron cryomicroscopy of DNA nanostructures"

September 24, Professor & Graduate Program Director Shelley Minteer, College of Arts and Sciences, St Louis University, USA, "Bioelectrocatalysis for energy conversion applications"

October 8, Ph.D. Lone Frank, Science Journalist and Author, Weeekendavisen, Copenhagen, Denmark, "Science Ð the great changer of minds"

October 29, Professor Daniel Otzen, Interdisciplinary Nanoscience Center, Aarhus University, Aarhus, Denmark, "Inhibiting alphaÐ synuclein aggregation: towards a cure for Parkinson's Disease?"

November 5, Doctor Jeffrey Karp, Laboratory for Advanced Biomaterials and Stem Cell-Based Therapeutics Harvard-MIT, Cambridge, USA, "Towards the next generation of advanced biomaterials and stem cell based therapeutics"

November 12, Professor Sebastian Doniach, Department of Physics, Stanford University, Stanford California, USA, "XÐrays, biology and nanomachines"

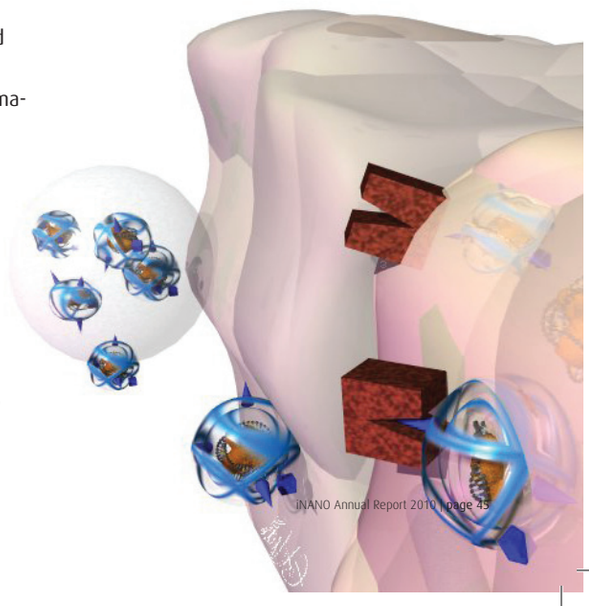
November 19, Professor Chris Xu, School of Applied Physics and Engineering, Cornell University, Ithaca, New York, USA, "Technology development for in vivo deep tissue imaging"

November 26, Professor Bente Vestergaard, BIOSAXS group – Biostructural Research, Department of Medicinal Chemistry, Copenhagen University, Denmark, "Structural Investigations of Protein Fibrillation – centered around Small Angle XÐray Scattering solution analysis"

December 3, Professor Hendrik Dietz, Laboratory for Bimolecular Nanotechnology, Physics Department, Technische Universitet München, Munich, Germany, "DNA in a machine world"

December 17, Professor Philip Hofmann, Physics Department, Aarhus University, Aarhus Denmark, "Topological insulators"

December 20, Professor Lene Vestergaard Hau, Harvard School of Engineering and Applied Physics/ Hau Lab, Harvard University, Cambridge, Massachusetts, USA, "Quantum control of light and matter…From the macroscopic to nanoscale"



PhD theses

Michael Brammer Sillassen, Synthesis and Ionic Conductivity Properties of Stabilized ZrO2 Thin Films

Henrik Fanø Clausen, Investigating Molecular Interactions. Utilization of Experimental Electron Density Distributions and Hirshfeld Surfaces

Mette Louise Hallager Mantel, Expanding the Scope of Palladium-Catalysed C-C and C-N Bond Formations

Rolf Hejle Taaning, Imide-Alkene Couplings Promoted by Single Electron Reducing Agent Samarium (II) Iodide and Synthesis of Potential and Known Antibiotics

Tina Mittag, Synthesis and Application of Peptide Analogues of the Fibril-Forming peptide Sequences HIAPP22-27 and HIAPP 20-29

Carsten Scavenius Sonne-Schmidt, Inter-(alfa)-Inhibitor a proteoglycan in the Extracellular Matrix. A characterization of inter-(alfa)-inhibitor - structure, function and interactions in the extracellular matrix.

Kasper Runager, Biochemical and Structurel Charcterization of TGFPIp in relation to Corneal Dystrophies

Morten Keller Grøftehauge, Exploring the Neurotensin Binding Pocket of Sortilin via Structural Biology and Fragment Screening for Functional Sites

Morten Østergaard Andersen, Delivery of RNA interference therapeuts from Scaffolds. Modulation of inflammation and stem cell differentiation for tissue engineering applications

Anna Sigrid Pii Svane, Liqiud stateNMR investigation of peptide conformations and interactions. The peptide hormone glucagon and a uPA inhibiting cyclic peptide

Christian Smith, Long-period gratings and applications for mode conversion

Ebbe Juel Bech Nielsen, Gene silencing in the Respiratory System - Mucosal and systemic delivery of polymerbased siRNA therapeutics

Federico Masini, Chiral induction in molecular surface assemblies and surface functionalization by covalent organic frameworks

Jacob Becker-Christensen, Synthesis and Characterisation of Nanostructured Catalyst Materials for Biofuel Production

Jenny Malmström Pendred, Design and Characterization of Functional Biointerfaces. Protein Patterns and Cell Adhesion

Jerzy Jòzef Dorosz, Biophysical characterization of peptide interactions with biomimetic membranes. Study on a prion fragment PrP (106-126) and an antimicrobial peptide Novicidin

Jonas Ørbæk Hansen, Fundamental processes on TiO2 (110) studied under dark and UV-light conditions

Karin Dooleweerdt, New Methods for Transistion Metal Catalyzed C-N Bond Formation. Introduction of Nitrogen Substituents onto Indole Scaffolds and Amidation of Aryl Halides and Sulfonates

Katrine Bilberg Hansen, The Toxicity of silver nanoparticles in fish

Kresten Bertelsen, Oriented solid-state NMR Spectroscopy. Characterization of the static and dynamic conformation-heterogeneity of small membrane bound antibiotic peptides

Krithika Venkataramani, Non-contact Atomic Force Microscopy Studies of Metal Oxide Surfaces and Oxide Supported Metal Nanoclusters

Lasse Ramsgaard, The Role of the Receptor for Advanced Glycation End-products in the Pathogenesis of Silicosis and Acute Lung Injury

Louise Carstensen Gjelstrup, A Study of the avidity binding pattern-recognition proteins B2-integrinsand mannanbinding lection (MBL), which play central roles in the innate immune system

Maria Therese Sundh, Novel Supported Membranes. Influence of Lipid Composition and Substrate Curvature on Vesicle Rupture

Marie Østergaard Pedersen, Solution and solid-state NMR of insoluble proteins. Amyloid B in Alzheimer's disease and the antenna protein CsmA

Nataliya Kalashnyk, Self-assembly of organic molecyles on metals and thin insulating films: Hydrogen-bonded systems, chiral induction and peptide aggregation

Simon Metz Mariendal Pedersen, Investigations of metabolic response to probiotic diet intervention and longevity selection

Søren Lundsted Poulsen, Methodologies for measuring the degree of reaction in Portland cement blends with supplementary cementitious materials by 29Si and 27A1MASNMR Spectroscopy

Patents

C.E. Bünger, S.H. Hein, J.V. Nygaard, J. Kjems, D.Q.S. Le, Tissue Scaffold with Controlled Drug Release, priority application, PA 2010 70443

F. Besenbacher, C.E. Bünger, J. V. Nygaard, M. Foss, D.Q.S. Le, Implant for treatment of skeletal deformities, priority application PA 2010 70123.

M. Bauerek, C. Poulsen, B. Raungaard, L. Schauser, J. B. Søe, Cholesterol esters to reduce cholesterol uptake, priority application GB 1007668.5.

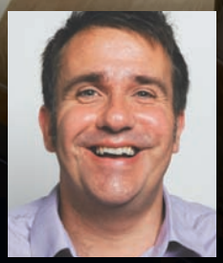
J.B. Skibsted, S. Lopez, F. Besenbacher, D. Herfort, Alkali Sulphate activated composite cement, priority application EP, 09160271.4.

S. Sørensen, J. Kjems, B.S. Sørensen, T. Østergaard, Methods and compositions for regulation of HER4, priority application PA 2010 70082

iNANO administration

Backrow: Kaj Jensen, Peter Thostrup and Leif Schauser
Frontrow: Sys Zoffmann Glud, Julie Terndrup, Rebeca Thostrup og Charlotte Illum Nielsen

Appointment of staff associated withe iNANO in 2010



MONDAY 31. MAY 2010

Ken Howard awarded tenure position as Associate Professor at iNANO and MBI.

Ken Howard is now employed in a tenure position as Associate Professor at iNANO and Department of Molecular Biology where he will carry out research within the field of nanomedicine.

WEDNESDAY 28. APRIL 2010

Philip Hofmann appointed Professor with Special Responsibilities

As of 1 March 2010 Philip Hofmann has been employed as a professor with special responsibilities in experimental physics at the Department of Physics and Astronomy, the Institute for Storage Ring Facilities and iNANO.

TUESDAY 19. JANUARY 2010

Peter A. Andreasen appointed professor of cancer reseach

Peter A. Andreasen has been appointed Professor at the Department of Molecular Biology, Aarhus University, with a special view to research into the mechanisms underlying the spread of cancer cells in the body.

Senior staff

Andreasen, Peter
Baatrup, Erik
Balling, Peter
Besenbacher, Flemming
Birkedal, Henrik
Birkedal, Victoria
Bøttiger, Jørgen
Daasbjerg, Kim
Duch, Mogens
Dong, Mingdong
Enghild, Jan Johannes
Ferapontova, Elena
Foss, Morten
Gao, Shan
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
Kingshott, Peter
Kjems, Jørgen
Knudsen, Birgitta
Knudsen, Charlotte Rohde
Kristensen Mogens
Larsen, Arne Nylandsted
Lauritsen, Jeppe Vang
Linderoth, Trolle René
Lægsgaard, Erik
Malmendal, Anders
Mamdouh, Wael
Meyer, Rikke L.
Nielsen, Brian Bech
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
Sørensen, Esben Skipper
Stapelfeldt, Henrik
Stensgaard, Ivan
Sutherland, Duncan
Svaneborg, Carsten
Vosegaard, Thomas
Xu, Xuebing
Zelikin, Alexander

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