Mission Statement

The scope of UCPH Nanoscience – a student research journal is to document the breadths of research performed by students at the Nano-Science Center at the University of Copenhagen. This is accomplished by publishing all bachelor theses submitted to obtain a bachelor degree in nanoscience. Each volume of the journal will contain up to four issues, and will be published online at:
tidsskrift.dk/index.php/NanoVidenskabKU
The journal is not indexed in any abstracts services, and the papers may only be cited as opinion pieces, bachelor theses, and reports.

Target audience

Current, past and prospective students of nanoscience and the related disciplines, and the faculty of the Nano-Science Center, University of Copenhagen.

Contributors

The main contribution will come through the mandatory submission of all bachelor theses as articles in this journal. 'Forskningspraktik' research trainee reports must also be submitted in order to qualify for examination. All theses and reports must be written in the supplied templates (Word/LaTeX) and adheres to a strict page limit, supporting information may be included. For each report, a short summary is written by the editorial staff. The summary will feature a photo of the student.
Students are encouraged to submit research articles written as part of their course work to the journal. Shorter letters, full papers, and reviews will be included in the journal as papers
Submitting of opinion pieces and relevant News & Views items are encouraged from students and faculty at the Nano-Science Center.

Content

Each issue will contain:

- Masthead
- Editorial
- Table of content
- News & Views
- Papers
- Theses
- Reports

The Papers and Reports sections will only be included if contributions have been received.

Editorial line & Peer review

The editors consider the quality of the submitted papers and the tone of the opinion pieces. Reports and thesis are submitted for examination and is published as is. There is no peer review on the theses and reports.

Thomas Just Sørensen
Editor-in-chief

Professor Bo W Laursen
Director of the Nano-Science Center

Professor Per Hedegård
Head of studies, Nanoscience

Picture Per Hedegård is the Head of studies for the nanoscience degree programme and Professor of Physics at the University of Copenhagen.

Picture Bo W. Laursen is the Director of the Nano-Science Center and Professor of Chemistry at the University of Copenhagen.

Thesis in this issue

The following students have graduated with a BA in nanoscience in 2017. Their theses have been included in this issue of UCPH Nanoscience.

Thesis marked by an asterix (*) are under embargo and will be published in a later issue of UCPH Nanoscience.

UCPH NanoScience, 2018, 1, 201801 10p

Optimization of experimental procedure for assessing transition metal FRET in LeuT by Alma Winther Sørensen

Alma Winther Sørensen worked in the Neuropharm and Genetics lab that with, amongst other things, Neurotransmitter Sodium Symporters in relation to drug addiction and treatment.

Almna graduated Nanoscience B.Sc. June 2017, where she focused on primarily biology and neuroscience.

Supervisor: Lektor Claus Juul Løland

Thesis abstract: Neurotransmitter sodium symporters (NSSs) are important for the regulation of neurotransmitters, such as dopamine and serotonin, which are involved in addiction and depression, along with several other diseases. The bacterial NSS, LeuT, has been proven to be a good model protein for the mammalian NSSs. Conformational changes of LeuT can be examined using transition metal ion F¨orster Energy Resonance Transfer (tmFRET), where the energy transfer between a fluorescein dye and a di-histidine bound Ni^{2+} is measured. When utilizing tmFRET, free Ni^{2+} is added to the solution, which also adds to the unspecific quenching signal detected. It is therefore necessary to remove the signal from the unbound Ni^{2+},in order to properly investigate the impact of specific bound Ni^{2+}. Here we investigate whether the effect of Zn^{2+} can be used to inhibit FRET contribution from specifically bound Ni^{2+} and thereby isolate the non-specific signal. We found that Zn^{2+} can competitively inhibit the binding of Ni^{2+} to the di-histidine motif of LeuT, thereby representing an easier, and perhaps more consistent, method for removing the signal from unbound Ni^{2+} during tmFRET measurements.

UCPH NanoScience, 2018, 1, 201802 12p

Weyl semimetals in models for ultracold atoms by Andreas Hansen

Andreas Hansen

Supervisor: Dr. Michele Burrello

Thesis abstract: I study the effect of a non-Abelian gauge potential on a Weyl semimetal phase appearing in a particular 3D tight-bindingmodel of fermions. The lattice I consider is characterized by a C_3 rotational symmetry and by staggered $\pi/2$ magnetic fluxes on the triangular plaquettes in its horizontal planes. The energy spectrum is characterized by both singleWeyl points with linear energy dispersions in all three momenta directions, and double Weyl points with quadratic energy dispersions in two directions and linear dispersion along the axis of the rotational symmetry.

UCPH NanoScience, 2018, 1, 201803 10p

Platinum nanoparticles in photothermal therapy of cancer cells by Bunya Sarmad Aswad and Iliriana Qoqaj *

Dunya Sarmad Aswad worked in the Optical Tweezers Group at the Niels Bohr Institute that work at the cross roads of physics, optics, biophotonics, chemistry molecular biology, and medicine.

Dunya has a B.A. in Nanoscience from the University of Copenhagen (U CPH), with a focus on nanobiophysics and nanomedicine. Dunya is currently studying my Master degree in Nanoscience and Technology in Beijing, China at Sino-Danish Center (SDC).

Iliriana Qoqaj worked in the Optical Tweezers Group at the Niels Bohr Institute that work at the cross roads of physics, optics, biophotonics, chemistry molecular biology, and medicine. Iliriana has a B.A. in

Nanoscience from the University of Copenhagen (UCPH) focused on nanobiophysics/nanomedicine.
Iliriana is currently studying my Master degree in Nanoscience and Technology in Beijing, China at Sino-Danish Center (SDC).
Supervisor: Postdoc Henrik Klingberg
Thesis abstract: Noble nanoparticles are potential photothermal therapy agents, due to their properties, such as ability to modify particle surface chemistry, and efficient light-to-heat conversion. In this work, we study the possible application of platinum nanoparticles as agents in photothermal therapy, their uptake, and toxicological response in the human ovarian cancer cell line (SK-OV-3) by flow cytometry. No oxidative stress, or toxicological response of the platinum nanoparticles was observed in the cells. Laser irradiation revealed photothermal destruction of SK-OV-3 cells exposed to 70 nm platinum nanoparticles at power density 45 W/cm2 after 5 minutes using an 808 near infrared laser.

UCPH NanoScience, 2018, 1, 201804 8p

Synthesis and characterization of $CuCrO_2$ delafossite nanoplatelets through Rietveld refinement and Pair distribution function analysis by Emil Thyge Skaaning Kjær

Emil Thyge Skaaning Kjær work with structure determination of crystallographic challenged materials using advanced x-ray and neutron techniques.
Emil is an enthusiastic supporter of the "Putte for president" campaign. I like not walking at the beach and when seeing people drinking Fernet Brance.
Supervisor: Adjunkt Kirsten M.Ø. Jensen
Thesis abstract: Delafossite (ABO_2) nanostructures such as $CuCrO_2$ nanoparticles have shown promising properties indye-sensitized solar cells (DSSCs). Previous studies have shown that changing the metal on either the A or B site in the structure, influences both the conditions required to synthesize delafossite compounds, their properties, and their tendency of forming nanocrystals or bulk particles. The crystallites can further be doped changing the conductivity further. Here, we present a series of syntheses with varying parameters, illustrating how the conditions must be optimized to obtain the pure delafossite $CuCrO_2$ phase. Structure characterization was done through Powder X-ray Diffraction (PXRD) showing change in crystallite size with increasing synthesis time and temperature. By varying both temperature and time, the amount of secondary phase (CuO) in the final product can be minimized. It was only possible to synthesize pure delafossite when certain criteria regarding pH, temperature and time were met. Rietveld refinement of the PXRD data showed anisotropic nanocrystallites with approximate sizes of 130x130x40Å with the trigonal delafossite unit cell. However, the crystallites are too small and anisotropic to give a satisfying fit using conventional Rietveld refinement, and the sizes were obtained through anisotropic "no rules" model. Pair Distribution Function (PDF) analysis of X-ray total scattering data were used to obtain further understanding of structural disorder in the crystallites.

UCPH NanoScience, 2018, 1, 201805 6p

Heterogeneous Nucleation of Calcium Carbonate: Effects of Substrate Chemistry by Lasse V. Nikolajsen

Lasse V. Nikolajsen work in the nanogeo group, researching surface physical chemistry. Particularly calcium and iron based minerals.
Lasse is a nanoscience bachelor student, and has followed mostly nanochemical courses. Lasse is interested in studying surface physical chemistry and the intermolecular interactions occurring in near surface environments.
Supervisor: Adjunkt Karina K. Sand
Thesis abstract: Investigating heterogeneous calcium carbonate nucleation is essential in the pursuit to the barriers of nucleation. However, heterogeneous calcium carbonate systems are difficult to characterize due to the influence of homogeneous nucleation. Homogeneous nucleation must be removed in order to reliably report the saturation indices used in the experiments. In this paper, homogeneous nucleation and heterogeneous nucleation are experimentally examined with atomic absorption spectroscopy, optical microscopy and ultraviolet-visible spectroscopy. The impact of homogeneous nucleation on concentration and the correlation between concentration and induction time are investigated. We document a significant impact on concentration suggesting data from current literature is compromised. Based on data,

we propose a concentration range of 0.7 mM – 0.9 mM for obtaining barriers to nucleation using optical microscopy. Learning how surfaces influence the barriers and kinetics of CaCO nucleation can increase our understanding of biomineralization and improve carbon sequestration.

UCPH NanoScience, 2018, 1, 201806 7p

Local Current Through Helical Orbitals by Louise Oxen Høgh Hyllested

Louise Oxen Høgh Hyllested worked in the molecular electronics theory group, researching molecules ability to transport electrons through chemistry and physics. Louise is a student interested in chemistry and physics and have mainly followed courses relating to the theory.

Supervisor: Lektor Gemma C. Solomon

Thesis abstract: Traditional chemical research has given great information about the physical properties of molecules. This research provides understanding of how molecules work in the classical ways, but the limit is reached when molecules are used in a non-traditional way. Now molecules can be inserted in molecular junctions, which makes it possible to examine molecules in new ways. Recent theoretical work has shown that some linear molecules can have helical orbitals. Here the question of interest is whether the current density around these particular molecules are affected by the helical orbitals and the coupling of the electrodes. We show that the helical orbitals in combination with the coupling of the electrodes, indeed has an impact on the current and that the orbitals contribute to a circular current around these linear molecules. As the understanding of the currents behavior around the molecules expand, it paves the way for new chemical questions about how we can control the current. For example, how helical current may induce magnetic properties in non-magnetic molecules, and how chemical substituent can be used to impact these effects.

UCPH NanoScience, 2018, 1, 201807 10p

Predicting insertion: external force application onto cells allow nanowire arrays to insert into cytosol by Nicolai Vanggaard Bærentsen*

Nicolai Vanggaard Bærentsen explore innovative interfaces of newly developed nano-tools with biological samples for the development of novel biosensors to be used for pharmacological investigation and diagnostics. Such new methods are developed in the perspective of personalized medicine, providing well-suited therapies (better efficiency and limited side effects).

Emphasis is put on the exploitation of novel nanotechnologies and biophysical techniques for the investigation of G protein coupled receptors (GPCRs) representing major drug targets.

Nicolai holds a bachelor degree in nanoscience from University of Copenhagen and currently studying a semester in China at the SDC programme at University of Chinese Academy of Sciences. Enrolled as nanoscience masters student at KU. Made my bachelor project in the Nanobio Group at KU, and had several courses taught by members of the group.

Supervisor: Karen Martinez

Thesis abstract: The use of vertical nanowires in biosensing application is limited by the extend of how efficient nanowires can reach the intracellular domains. Studies have found nanowire insertion to be successful through single nanowire experiments with high force pr. nanowire, using AFM. This is inadequate for producing high throughput analysis of several cells with multiple nanowires inserting in each cell. Here, we present a model for prediction of the nanowire insertion rates, when centrifugating cell samples down onto arrays of vertical indium arsenide nanowires, with a diameter of 100 nm, height of 3 mm and spacing of 3-5 mm. The model utilizes sedimentation rate of cells in conjunction with the centrifugal force field applied to objects subjected to centrifugation. Various conditions tested with the model, including lowering the temperature of the experiment from room temperature to 4 °C, show that cell viability is not negatively affected by any of the conditions. The insertion rate has been shown to be largely affected by the density of the nanowire array substrate, with a

lower density resulting in a higher NW insertion rate, as the model predicts. The percentage of cells with at least one successful nanowire insertion is, however, oppositely affected by density, as a higher density results in larger percentage of cells with successful insertions.

UCPH NanoScience, 2018, 1, 201808 8p

Speciation and structure of dipicolinate complexes and Eu(III) ions in solution by Patrick Nawrocki

Patrick R. Nawrocki work with tanthanide Coordination Chemistry. Patrick likes the movie "The Road to El Dorado"

Supervisor: Lektor Thomas Just Sørensen

Thesis abstract: Complexation between Eu(III) ions and dipicolinate tridentate ligands (DPA) have been studied to expand on our current understanding of structural and photophysical properties of lanthanides in solution. The dynamic ligand-exchange of labile lanthanide ions, has made it difficult to properly identify the bis ligated Eu(III) complex, as optical spectroscopy only reveals a weighted average of the present species. In this article, evidence for the bis ligated Eu(III) complex will be presented, which is a necessary component in accurately determining the binding constants and to gain further insight in the structureproperty relationship of the systems. Additionally, NMR, luminescence spectroscopy and X-ray scattering were used as structural corroboration to further establish the relationship between the solution structure and the intensities of Laporte parity forbidden *f-f* transitions, characteristic of the lanthanides.

UCPH NanoScience, 2018, 1, 201809 9p

Population size matters: The cause & effect of heterogeneous B1AR expression and its influence on receptor internalization by Sylvester Houstrup Langvad*

Sylvester Houstrup Langvad worked in the group of Karen Martinez that strives to explore the field of novel biosensors for pharmacological investigation and diagnostic.

When Sylvester is not studying nanoscience for the greater good, he is pondering philosophical trolley dilemmas and helping small kittens get down from trees. Study hard, play harder.

Supervisor: Karen Martinez

Thesis abstract: In cellular physiology, the impact of heterogeneous receptor expression is a topic that has recently started to receive much attention from the scientific community. However, much is still not understood about the specifics on the origin of this heterogeneity nor how it affects bulk measurements of heterogeneous population. While the literature often acknowledges this heterogeneity, it falls short of offering an explanation of what practical implications this variability may have. In this paper, we examine two methods for evoking protein expression of G Protein-Coupled Receptors, transient transfection and inducible cell lines, and show that these methods have markedly different expression variabilities. While the inducible cell lines have relatively homogeneous expression profiles, the transient transfected cells showed large variability to an extent that bulk measurements of transfected cells may yield misleading data. We hope that the results presented in this paper may inspire future research in the field to fully consider the effects of heterogeneous expression profiles.

New Nanoscience Bachelors

The following students have graduated with a BA in nanoscience in 2017. Their theses will not be published in UCPH Nanoscience.

Nicolai Ree conducted his bachelor's project in the group of Prof. PhD, Dr.Scient. Kurt V. Mikkelsen at the Center for Exploitation of Solar Energy, Department of Chemistry. Here we apply different electronic structure methods to calculate quantum chemical properties of molecules. Current projects involve the design and optimization of molecular energy storage and dye-sensitized solar cells. As well as, theoretical calculations of electrochemical properties.

During the bachelor in nanoscience, Nicolai worked on my first article and got it published just before obtaining my bachelor's degree:

N. Ree *et al.*, J. Phys. Chem. A, 2017, 121 (46), pp 8856–8865

Supervisor: Prof. PhD, Dr.Scient. Kurt V. Mikkelsen

Thesis title: A Methodology for Calculating Redox Potentials of Azulene Derivatives

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Tahreem Aejaz Bukhari is interested in nanobio and organic chemistry particularly with focus on medical applications. Tahremm's hobbies include reading lots of books, baking cookies and playing Pokémon. She also enjoys taking naps.

Chastine Fleischer Munk worked on structure determination of LeuT using tmFRET to investigate the hellical unwinding mechanism of TM5 and TM7.

Chastine spend 6 months on exchange in Australia petting koalas and taking selfies with kangaroos. Chastine's favorite ice cream is raspberry sorbet, and Chastine is a professional when it comes to faceplanting when she wakeboards (that's why Chastine looks lost sometimes).

Supervisors: Lektor Nikos Hatzakis & Lektor Claus Juul Loland,

Thesis title: Investigating LeuT TM5 and TM7 Hellical Unwinding Dynamics Using tmFRET.

Emil Vogt performs research in the field of physical chemistry. The groups research is aimed at understanding atmospheric radical reactions. They are able to determine the reactivity of molecules and radicals in a range of different reactions by determining reaction rate constants. Their research is also aimed at determining properties of atmospheric molecules and hydrogen-bonded complexes to achieve a better understanding of the mechanisms of aerosol formation.

Emil has chosen to specialize in the field of quantum- and computational chemistry. His main interest lies in the theory of properties concerning vibrational spectroscopy. In my bachelor project he developed a model for obtaining parameters for the Deng-Fan potential. Furthermore, Emil compared XH-stretching transition frequencies and oscillator strengths using a numeric potential, the Deng-Fan potential and the Morse potential.

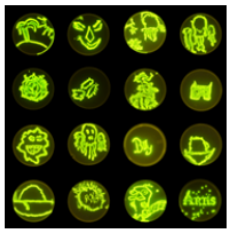
Supervisor: Professor Henrik Grum Kjærgaard

From students to students

A summer research project in Barcelona by Henrik Pinholt, Stud. Scient. Nanoscience 2016

For a long time, I have tried to find out how stem cells coordinate their collective behavior in the earlier developmental stages of fetal development. This work culminated the summer of 2016 in the form of three weeks of research at ”Centro de Régulación Genómica” (CRG) in Barcelona. The research was done in James Sharpe’s’ group: ”Multicellular Systems Biology” with aid from technician Heura Cardona under the observation of Sharpe. Our goal was to get more insight into the spatial regulation of the bone-inducing gene *SOX9* in the fingers of mouse fetuses. More specifically, we sought to investigate how cell environment affects *SOX9* expression due to effects of pressure from neighboring cells. We investigated this based on a model system: We grew mesenchymal EGFP-SOX9 stem cells from developing mice in micro cultures. The cultures were grown in homemade champers with the opportunity for pressure application with pistons. The pressure was meant to simulate cell condensations in chondrogenesis. In micro culture, these cells express a spatially periodic pattern of SOX9. This provides a model system to study the mechanism in charge of spatially positioning bone formation in digital regions and apoptosis in interdigital regions. We took CLSM pictures of the cultures, and studied the pattern changes due to pressure from the pistons. This probably sounds simple in theory, but it turned out to be quite troublesome to apply pressure to these cells without ruining the culture, and still being able to image the pattern. This heavily reduced the amount of usable data available. We did, however, manage to find indication towards a pressure-induced pattern change. Due to the lack of large amounts of proof, this study stands as an inspiration. My hope with this work is that it will add new perspectives to a field, which has mainly focused on spatial regulation through diffusing signals. This might not be the case in general, and new evidence suggest, that pressure might have influence not just on gene regulation locally, but also spatially. The problem is that this issue is rather difficult to address experimentally, and this is why this study is important. Because it provides a first attempt to investigate spatial gene regulation from compression in development.

Other news

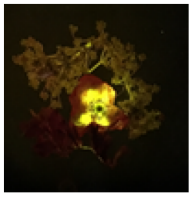


ARTiS: Art in Science

Art in Science or ARTiS is the outreach programme of Nano-Sceince center meant to use art to communicate science to a broad audience.
This includes an original approach to educate and engage children in scientific disciplines. It is furthermore a unique opportunity for scientists to talk about their work in an original context.
ARTiS 2017 was composed of the yearly picture contest, children boot camps and the yearly picture exhibition. About 100 pictures were part of the picture contest 2017 attracting 3,500 people to the ARTiS 2017 exhibition in the ceremonial hall of University of Copenhagen during Culture Night.
This programme is headed by Karen L. Martinez, associate professor and head of the BioMeP group. It has been sponsored by Lundbeckfonden and University of Copenhagen.

ARTiS 2017 Winners

1st prize 2017
“Beauty in seawater” by Jannicke Wiik-Nielsen, Norwegian Veterinary Institute.



Young Art-scientist Prize 2017
”Flower” by Andrii Lapytskyi