Norwegian

NanoSymposium

Quality Panorama Hotel, Trondheim

16 – 17 October 2019

PROGRAMME

NTNU

Nanooptics for trapping and analysis of nanoparticles

Olav Gaute Hellesø
University of Tromsø, UiT

olav.gaute.helleso@uit.no

Extra-cellular vesicles are cell-fragments that can give important information about cell-to-cell communication and possibly about the state of the body. Optical trapping of micro-particles is well established. Can the principles be combined with nanooptics to trap and analyse cell-fragments? A description will be given of the principles, challenges and possible ways ahead.

Unraveling the intricate in vivo fate of active-targeting nanomedicines

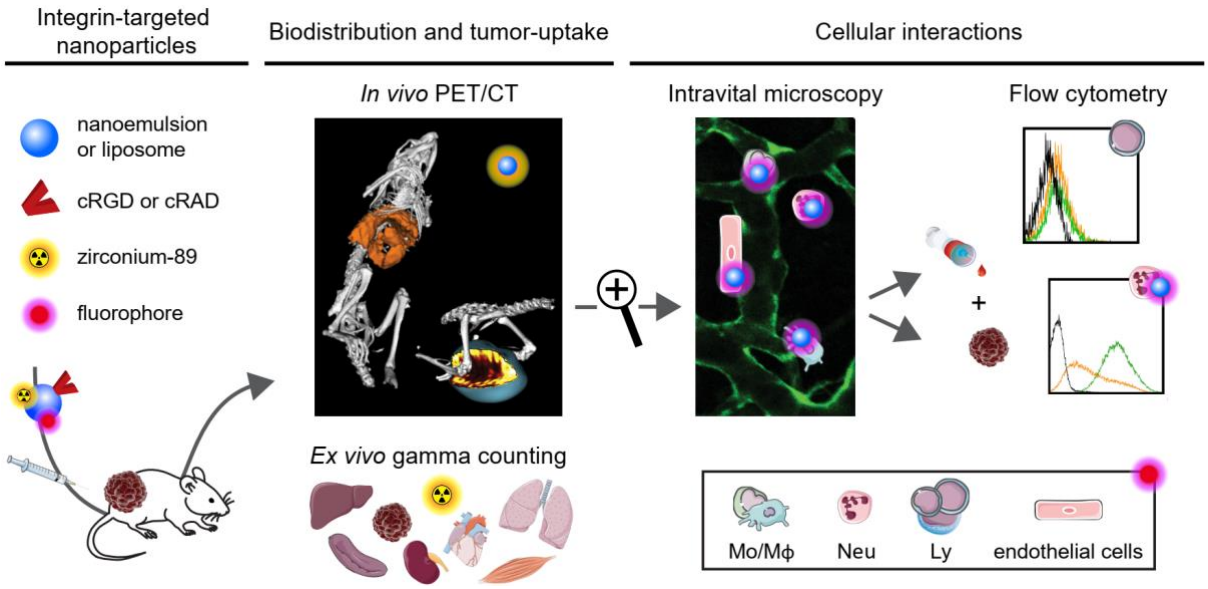
Alexandros Marios Sofias[1,2], Carlos Pérez-Medina[2,3], Willem J.M. Mulder[2,4], Sjoerd Hak[1].

[1] Norwegian *University of Science and Technology, Trondheim, Norway*
[2] *Icahn School of Medicine at Mount Sinai, New York, USA*
[3] *Centro Nacional de Investigaciones Cardiovasculares Carlos III, Madrid, Spain*
[4] *Eindhoven University of Technology, Eindhoven, Netherlands*

alexandros.m.sofias@ntnu.no

One of the most widely studied ligand-mediated nanomedicine targeting strategies relies on nanoparticle decoration with the cRGD ligand. This ligand binds to integrins expressed on activated endothelium in inflammatory and cancerous lesions. Despite their widespread use and even clinical assessment, the shreds of evidence for their targeting potential towards activated endothelium are mostly based on in vitro assays or ex vivo immunohistochemistry.

Using a highly complementary approach where we integrated PET/CT imaging, and real-time intravital microscopy with flow cytometry, we studied the cRGD-nanoparticle targeting mechanisms in vivo. This unique approach allowed for discovering that cRGD-nanoparticles are extensively taken up by circulating immune cells, with which the nanoparticles home to angiogenic lesions. Surprisingly, the anticipated direct targeting towards activated endothelium was inefficient. This important realization establishes immune cell-mediated targeting as an independent mechanism to be studied for nanotheranostic purposes.



The role of conformational dynamics in protein function; Deciphering CRISPR-Cas12a and hydrolytic lipase function by studies at the single molecule level

Magnus B Sletfjerding[1,4], Johannes Thomsen[1], Simon B Jensen[1], Freja J Bohr[1], Søren SR Nielsen[1], Camilla D Thorlaksen[1], Matias E Moses[1,2] and Nikos S Hatzakis[1,,53]

[1] Novo Nordisk Center for Protein research, University of Copenhagen,
[2]Novozymes A/S, Bagsværd, Denmark,
[3]Department of Chemistry and Nano-Science Center, University of Copenhagen.
http://nano.ku.dk/english/research/nanoenzymes/

[4]Presenting Author: mbs@chem.ku.dk
[5]Corresponding Author: hatzakis@chem.ku.dk

Enzymes regulate a plethora of vital cellular processes, and aberration in their function can result in countless disease states. Enzymes also harbour essential industrial applications, including drug synthesis and detergent development. Deciphering how structural dynamics and conformational sampling dictate enzyme function remains a key challenge, both in functional design of enzymes and to understand fundamental biological processes.

I will present how single-protein fluorescence microscopy measurements reveal previously unknown information of the structure-function relationship of a wide range of enzymes, ranging from industrial lipases to the well-known CRISPR system. We show how single-particle tracking of Thermomyces Lanuginosus Lipase (TLL), on native trimyristin substrate surfaces unveiled distinct patterns of lipase diffusional properties and correlation to surface morphology. Furthermore, we show how single-molecule FRET experiments, coupled with cryo-EM structures of CRISPR during cleavage divulged the thermodynamics and kinetics governing conformational activation during DNA hydrolysis.

Recent group's relevant publications

1. *S. Stella et al., Cell **175**, 1856, 2018.*
2. *T. Laursen et al., Science **354**, 890, 2016.*
3. *M. E. Moses, et al Methods Enzymol. **581**, 227, 2016.*
4. *M. Li et al., J. Am. Chem. Soc. **137**, 16055, 2015.*
5. *N. S. Hatzakis et al., J. Am. Chem. Soc. **134**, 9296, 2012.*
6. *N. S. Hatzakis et al., Nat. Chem. Biol. **5**, 835, 2009.*

Piezoelectric ceramics as bone replacement material

M. Rotan[1], K. K. Poon[1], K. S. Fedje[1], K. Karkuszová[2], F. S. Andersen[1], M. Zhuk[1], M. O. H. Solum[1], M.-A. Einarsrud[1], J. Glaum[1]*

[1]Department of Materials Science and Engineering, Norwegian University of Science and Technology, Trondheim, Norway

[2]Institute of Materials Science and Engineering, Brno University of Technology, Brno, Czech Republic

*magnus.rotan@ntnu.no

Research has shown that bone exhibit piezoelectric characteristics and that electric charges positively affect its ability to rebuild and remodel. By utilizing a piezoelectric ceramic as an active bone implant material, it is believed that a shorter recovery period after surgery can be achieved, as well as a stronger bonding between bone and implant material adding time to the implant's lifespan. It is therefore of interest to investigate the possibility to use piezoelectric ceramics as an active bone replacement material by mimicking nature's own healing mechanism.

In the development of piezoelectric ceramics for biomedical application there are several aspects that need to be considered and challenges to overcome. Cytotoxicity and biocompatibility, design and structure, mechanical compatibility, electromechanical endurance, chemical integrity, processing and pre-implementation procedures are all important factors that need to be evaluated, studied and addressed prior to application. The current research study relates to the development of lead free barium titanate and potassium sodium niobate based compounds and their prospective use as a piezoelectric implant material. Firstly, we show how microstructure and porosity largely influence the piezoelectric performance and further how microstructure tailoring can improve the properties for the implant. Second, the possibility of using existing metal-based implant material as scaffold and adding piezoelectric properties by surface treatment has been investigated by means of a spray coating technique. It is shown that obtaining a good bonding between the metal and the ceramic is not straight forward and that the interface chemistry plays an important role for a successful bonding of the adhesion layer. A second approach to surface coating is by spin coating of an aqueous precursor solution and some preliminary results from the study will be presented.

Taking control of innate immunity with nanobiologics

Willem J. M. Mulder[1,2,3]

[1]*Biomedical Engineering and Imaging Institute, Department of Radiology, Icahn School of Medicine at Mount Sinai, New York, NY, USA.*
[2]*Department of Oncological Sciences, Icahn School of Medicine at Mount Sinai, New York, NY, USA.*
[3]*Laboratory of Chemical Biology, Department of Biomedical Engineering and Institute for Complex Molecular Systems, Eindhoven University of Technology, Eindhoven, Netherlands*

Immunotherapy is revolutionizing the treatment of diseases. Most of the immunotherapy strategies currently being developed engage the adaptive immune system. In recent years, emerging evidence has shown that the innate immune system displays long-term changes in its functional program through metabolic and epigenetic programming of myeloid cells (monocytes, macrophages, dendritic cells). Therefore, targeting myeloid cells and their progenitors is a powerful 'therapeutic framework' to regulate the delicate balance of immune homeostasis, priming/training and tolerance. This Presentation will showcase how nanobiologic-based immunotherapies can be applied to achieve long-term therapeutic benefits in detrimental diseases, including cancer and cardiovascular diseases as well as to prevent organ rejection after transplantation. In addition, a translational workflow involving innovative multimodality imaging approaches and large animal models will be discussed.

Electron beam lithography: principles and applications for cell studies

Jakob Vinje[1], Sindre Ullmann[2], Kai S. Beckwith[2], Pawel Sikorski[1]

[1]Dept. of Physics, Norwegian University of Science and Technology, NTNU. Norway [1]Centre of Molecular Inflammation Research, Dept. of Molecular and Clinical Medicine, Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, NTNU.

jakob.vinje@ntnu.no

Electron beam lithography (EBL) is arguably one of the cornerstone techniques in modern nanofabrication. It relies on defining structures in films of electron sensitive polymers coated on flat surfaces. Energy transferred from the electron beam causes changes in the solubility of the polymer and after immersion in a solvent, nanostructures can be obtained. State-of-the art EBL systems are able to fabricate structures with sizes below 10 nm and due to its flexibility EBL is used in a large variety of fields[1].

One promising area of application is in the study of living systems. EBL can be used to fabricate nanostructures for use in advanced systems for life-science related research, such as in diagnostic tools and for novel drug-delivery systems.

In this presentation I will discuss some fundamental concepts of EBL, possibilities, process limitations and how we use EBL to fabricate glass surfaces decorated with polymer nanostructures to study cells[2].

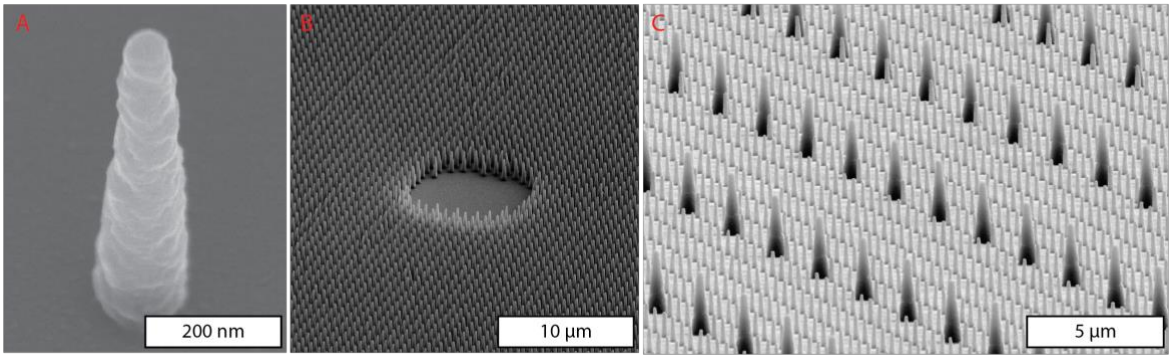


Figure 1: SU-8 nanopillars made with EBL on glass surfaces.

[1] Cui, Z. (2017) *Nanofabrication* https://doi.org/10.1007/978-3-319-39361-2

[2] Beckwith, K. S., Ullmann, S., Vinje, J., & Sikorski, P. (2019) *Small*, 1902514. https://doi.org/10.1002/smll.201902514

AFM study cellulose nano-fibril swelling in water – relevance of nanofiber crystallinity

Vegar Ottesen[1], Per Tomas Larsson[2], Kristin Syverud[1,3]
[1]Norwegian University of Science and Technology, Dept. of Chemical Engineering
[2]RISE Bioeconomy
[3]RISE PFI

vegar.ottesen@ntnu.no

Cellulose nanofibrils (CNF) are of large and growing interest both in academia and in industry. Much of the appeal is due to CNF being an abundant, environmentally friendly, non-toxic, renewable material with appealing mechanical, rheological and toxicological properties. Better understanding of the material's properties and a larger, better toolbox to characterize same are of interest. In the current study we investigate the potential of AFM to characterize interactions between CNF (here from cotton) and fluids (here water).

CNF were prepared from cotton linter with two degrees of crystallinity (DoC) by high pressure homogenization. The fibrils had high (65 ± 2 %) or low (44 ± 2 %) DoC. DoC was altered by submersion in anhydrous ammonia (l). High resolution micrographs of CNF in air and in DI-water were recorded and used to assess swelling. Care was taken to image the same fibrils in both air and water. We found no significant (p=0.3143) correlation between swelling and DoC. No clear correlation between the size of the nanofibril and the swelling of same was revealed.

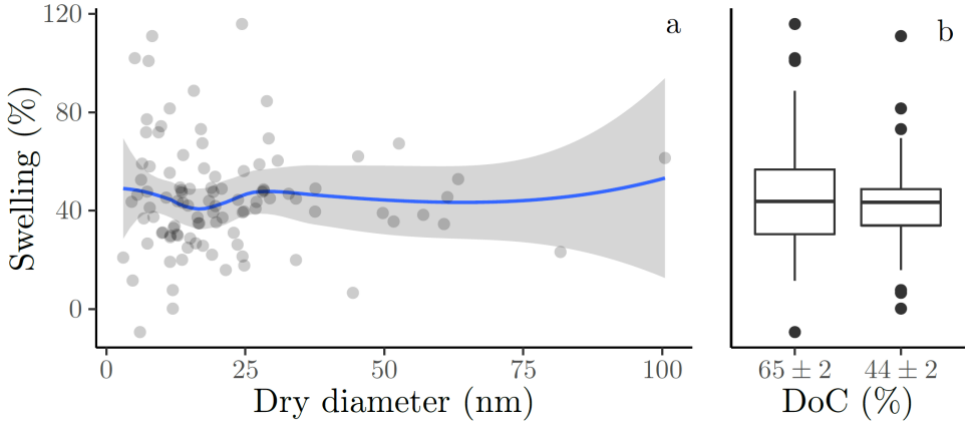


Figure 1 Loess regression of dry diameter versus swelling of fibrils (a) and Tukey box-plot of swelling vs. DoC (b). Both plots have the same y-axis. Each data point in a shown for clarity. Ribbon in a shows 95 % confidence interval, as reported by loess (in R). DoC in b refers to Degree of Crystallinity, as measured by $_{13}$C NMR

Gas sensors based on 2D heterostructures

Ozhan Koybasi[1], Ayaz Ali[2], Wen Xing [2], Marta Benthem Muñiz [2,3], Daniel Nilsen Wright[1], Takashi Taniguchi[4], Kenji Watanabe[4], Branson D Belle[2]

[1]*SINTEF DIGITAL, Forskeningsveien 1, NO – 0314, Oslo, Norway;*

[2]*SINTEF INDUSTRY, Forskeningsveien 1, NO – 0314, Oslo, Norway;*

[3]*École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland;*

[4]*Advanced Nanomaterials Laboratory, High Pressure Group, National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan*

Ozhan.koybasi@sintef.no

Graphene and graphene-like 2D layered materials such as transition metal dichalcogenides (MoS_2, WS_2, *etc.)* have attracted tremendous scientific and technological research interest over the last one and half decade. These materials offer excellent possibilities for developing ultra-sensitive sensors due to their unique properties such as high carrier mobilities, tuneable electronic structure, high surface to volume ratios and ease of functionalization. Hybrid structures consisting of different layers of 2D materials can lead to superior device performance and capabilities. Over the last few years, using NorFab facilities, we have developed an expertise in assembly of 2D material heterostructures and in fabrication of devices based on such materials that can be used for various sensing applications including gas detection. We have demonstrated the potential of hBN/MoS_2 devices to detect ultra-low concentrations of gases (in the low ppb level), which will be the main focus of the presentation.

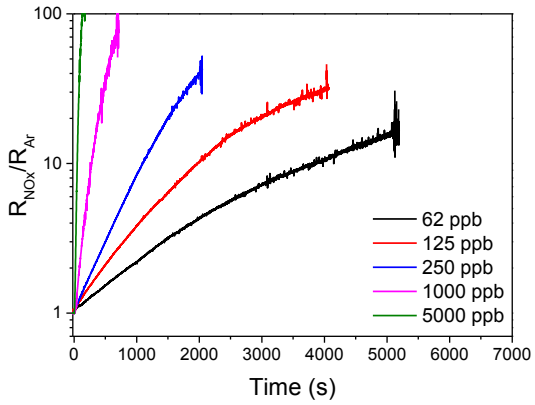


Figure 1. Response of MoS_2/hBN transistor to different concentrations of NOx, which is quantified by the change in resistance of MoS_2.

DNA functionalized magnetic nanoparticles encapsulated in silica/polymer shell for hydrological tracing

Anuvansh Sharma[1], Jan Willem Foppen[2], Thom Bogaard[3], Mari-Ann Einarsrud[1], Sulalit Bandyopadhyay[3,4].

[1]Department of Materials Science and Engineering, NTNU, Trondheim, Norway.
[2]Water Science and Engineering, IHE Delft Institute for Water Education, Delft, Netherlands.
[3]Department of Water Management, TU Delft, Netherlands.
[4]Department of Chemical Engineering, NTNU, Trondheim, Norway.

anuvansh.sharma@ntnu.no

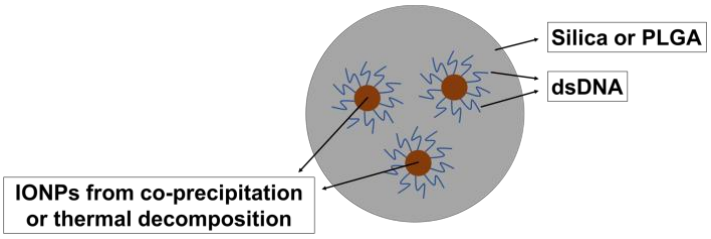


Figure 1. Schematic showing composition of DNA-based hydrological tracer.

Hydrological tracers find wide range of applications ranging from have determination of water flow paths, determination of the source of various contaminants, characterization of surface and ground water movement among others. The field of hydrology is however, plagued by the availability of different unique tracers which are usually fluorescent dyes and salts, whereby, restricting multiple tracer experiments. Several of the current tracers show limitations arising from toxicity and detection limits. The use of DNA in low concentrations is non-toxic to flora and fauna, therefore, is environmentally safe.[1] The underlying principle is to use DNA as a fingerprint for the tracers that would enable synthesis of virtually unlimited number of tracers, each carrying a specific DNA signal. For easy separation and qPCR analysis of tracers downstream, we plan to use magnetic fields for up-concentration, whereby requiring magnetic tracers that can be achieved using iron oxide nanoparticles (IONPs).

Here, we present fabrication of DNA-based hydrological tracers where the magnetic core is synthesized using co-precipitation (giving spherical NPs – magnetite) [2] or thermal decomposition (giving spheres (SNPs) or cubes (CNPs)).[3] We further report functionalization of the magnetic core using silanization or nanoprecipitation with the aim to encapsulate ssDNA or dsDNA (Figure 1). The NPs have been characterized using dynamic light scattering (DLS), zeta potential measurements, transmission electron microscopy (TEM) and DNA quantification using qPCR. Three different hydrological tracers are reported here, each encapsulating unique dsDNA, whereby enabling possible applications in multi-tracer experiments. qPCR results show successful encapsulation of dsDNA bound to IONPs inside monodisperse silica particles with high colloidal stability (zeta potential = -34 mV for magnetite, -37 mV for SNPs and -31 mV for CNPs). We report for the first-time encapsulation of dsDNA (80 nt) functionalized IONPs within poly lactic-co-glycolic acid (PLGA) NPs using a modified nanoprecipitation technique yielding hydrological tracers (~218 nm with magnetite and 243 nm with SNPs). These DNA-based magnetic tracers are expected to impact tracking of water flow paths using multiple tracers for both ground and surface water applications.

References

[1] J.W. Foppen, C. Orup, R. Adell, V. Poulalion, S. Uhlenbrook, Hydrological Processes, 25 2011, 3101 – 3106
[2] Puddu, M., Paunescu, D., Stark, W. J., & Grass, R. N. (2014). ACS nano, 8(3), 2677-2685.
[3] G. Singh, P.A. Kumar, C. Lundgren, T.A. van Helvoort, R. Mathieu, E. Wahlström, & W.R. Glomm, Particle & Particle Systems Characterization, 31 2014, 1054-1059.

Nanostructured conducting polymers for water treatment, metal recovery, and energy conversion and storage

Irina Chernyshova

Department of Earth and Environmental Engineering, Columbia University, New York, NY, USA.
Ic2228@columbia.edu
Department of Geoscience and Petroleum, Norwegian University of Science and Technology (NTNU), Trondheim, Norway.

irina.chernyshova@ntnu.no

Targeting challenges at the water-energy-raw materials-environment nexus is a critical expanding field which requires merging of ideas and approaches. In this context, of special interest is to expand application of conducting polymers beyond (opto)electronics and (bio)sensors, where they have already extensively been used due to their unique physico-chemical properties, low cost, and easy processability. One of the emerging application areas for conducting polymers is electric-to-chemical energy conversion such as CO_2 electroreduction and oxygen reduction reactions, where conducting polymers can improve catalytic activity and stability of incorporated inorganic nanoparticles or function as electrocatalysts by themselves. A totally new application area for conducting polymers is water treatment and metal recovery. Here, when combined with electrochemical approaches, conducting polymers can reduce cost- and make eco-friendlier removal of heavy metals and organic contaminants of emerging concern including microplastics, from polluted water, as well as recovery of valuable elements from their ultra-dilute solutions in complex matrices such as sea water and mineral tailings, thereby helping the society build smart circular economy. In my talk, I will explore advantages, challenges, and available strategies of inventing chemically stable high-surface area conducting polymers for these new application areas, as well as propose mechanisms behind the benefits provided by the polymers. I also will discuss my efforts to develop green synthesis methods for fabrication of electrosorbents and electrocatalysts based on conducting polymers.

New materials, new phases, and new functionalities on the nanoscale

Mikael Fogelström,

Chalmers University of Technology

Matter Waves and More

Bodil Holst

Department of Physics and Technology,
University of Bergen

Bodil.Holst@uib.no

In this talk I will present some recent highlights from research done in my group at the UiB Nanostructures Laboratory.

First I will show how matter waves can be used to measure the bending rigidity of 2D materials. Then I will show how matter waves can be used as a real space technique in a matter wave microscope and then I present the new FET-Open project Nanolace, a cooperation with Ingve Simonsen from NTNU. Here we will use metastable matter waves for mask-based lithography with nm resolution. Finally, I will present some recent work that we have done on the development of an icephobic, optically transparent graphene based coatings.

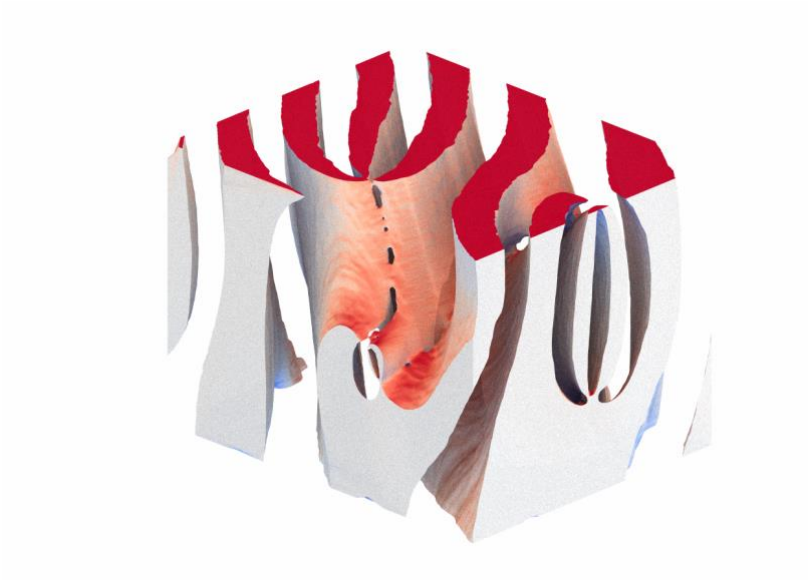
3D imaging of ferroelectric domain walls by FIB tomography

Erik Dobloug Roede[1], Aleksander Buseth Mosberg[2], Donald Evans[1], Antonius van Helvoort[2], Dennis Meier[1].

[1]Department of Materials Science and Engineering and [2]Department of Physics

Norwegian University of Science and Technology (NTNU)

erik.d.roede@ntnu.no



Ferroelectric domain walls show great promise for designing a new generation of nanoelectronic devices, enabling minimum feature size and low-power operation. They are naturally occuring, nanoscopic objects that display a rich range of functional properties. Recently, it has been shown that a single domain wall can replicate the response of devices such as switches and rectifiers.

The properties of a domain wall are given by its charge state, determined by the inclination angle relative to the electric polarization. Scanning probe techniques are standard for characterizing ferroelectric domains and domain walls. However, these image a 2D section of a 3D structure, and can not fully determine the charge state, precluding quantitative studies of domain walls.

We will present the 3D imaging of ferroelectric domain walls in $ErMnO_3$ using focused ion beam tomography. Our approach allows visualization of the domain structure and determination of the wall inclination angle with unprecedented precision throughout the sample volume. Gaining insight into the intrinsic properties of ferroelectric domain walls is a crucial step to understand their complex nanoscale physics and, ultimately, towards their application in future nanoelectronic devices.

Assembly of Van der Waals Heterostructures for high performance devices

Branson D. Belle[1], Maya N. Kutty[2], Øystein Dhal[1], Ayaz Al[3], Marta Benthem Muñiz[1,4], Per Erik Vullum[1], Takashi Taniguchi[5], Kenji Watanabe[5], Ozhan Koybasi[3]

[1]SINTEF INDUSTRY, Forskeningsveien1, NO 0314, Oslo, Norway;

[2]Centre for Materials Science and Nanotechnology, University of Oslo, PO Box 1048 Blindern, NO-0316 Oslo, Norway

[3]SINTEF DIGITAL, Forskeningsveien1, NO –0314, Oslo, Norway;

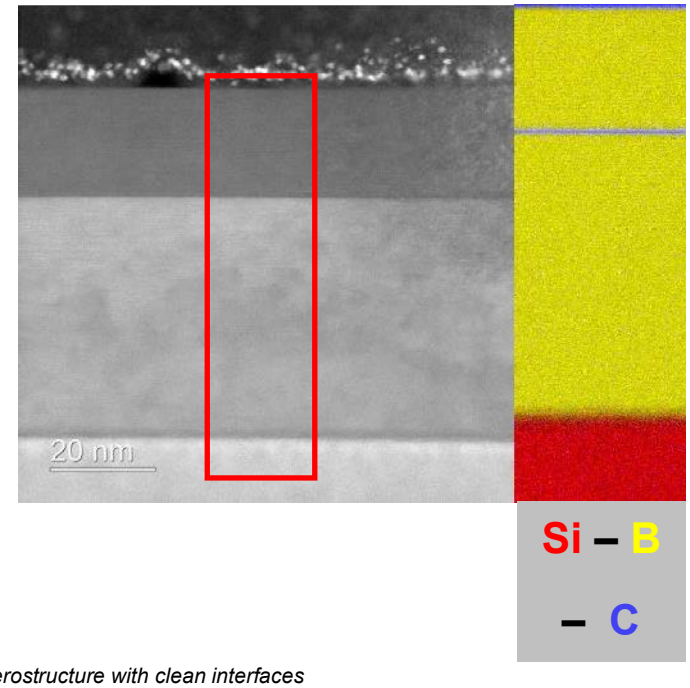
[4]École Polytechnique Fédéralede Lausanne (EPFL), Lausanne, Switzerland;

[5]Advanced Nanomaterials Laboratory, High Pressure Group, National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

branson.belle@sintef.no

The isolation of graphene has resulted in an increase in the interest in two-dimensional materials. These materials can be selected based on their electronic structure, ranging from semiconductor to insulator. Moreover, the vertical stacking of these materials into heterostructures results in new properties and applications leading to a plethora of opportunities. In this talk, I will present methods to assemble Van der Waals heterostructures with clean interfaces. I will also discuss in detail their subsequent patterning into functional devices along with interface characterisation. The work presented has been carried out in Minalab, Nanolab and NorTem facilities.

Figure 1: Electron Energy Loss Spectroscopy from a cross section of a hexagonal boron nitride/graphene/hexagonal boron



nitride Van der Waals Heterostructure with clean interfaces

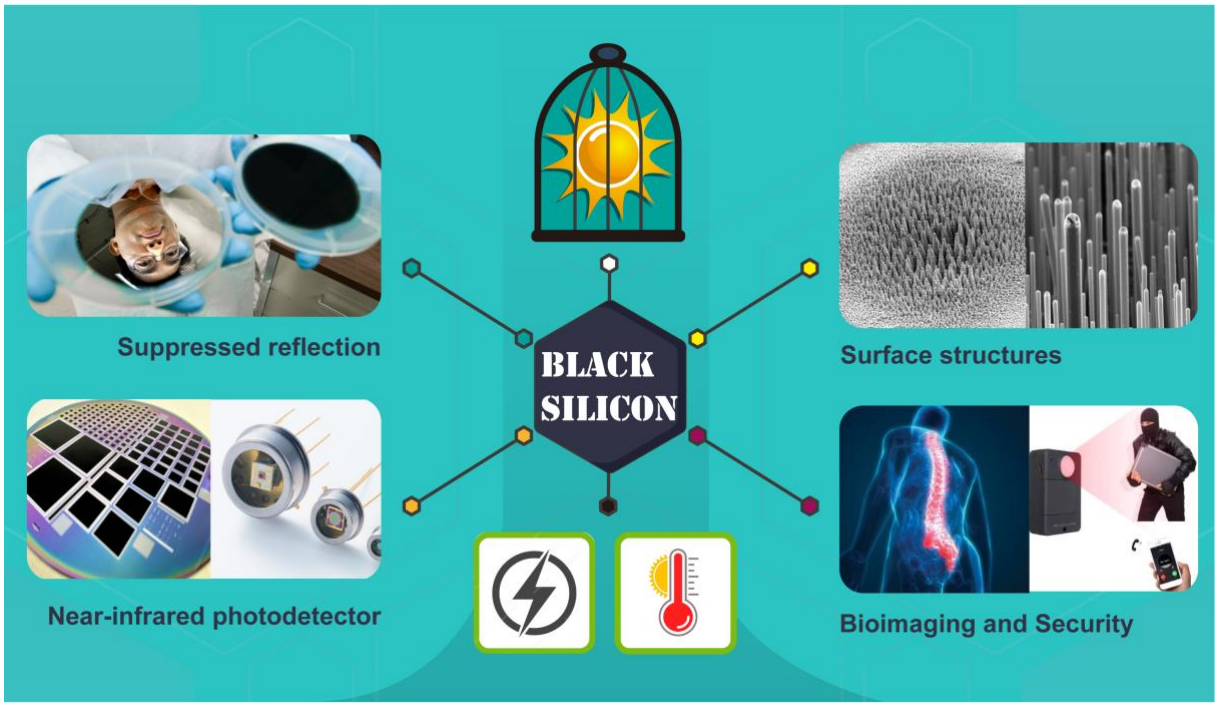
Black silicon fabrication and its applications

Zengxing Zhang[1], Kaiying Wang[1]

[1]University of South-Eastern Norway, Department of Microsystems

Kaiying.wang@usn.no

Black silicon, as a family member of silicon semiconductor materials, has a unique light trapping capability and presents "black" colour. Such behaviour is originated from reflection suppressed and scattering of micro/nanostructured surface morphology. The micro/nanostructure surface traps visible light energy through internal multi-reflection, scattering and light-matter coupling. Only a few photons of incident light can escape from the surface. In this work, with the help of metallic particles-induced plasmon effect and geometric configuration, we demonstrate that infrared light wavelength photons end up being captured as well. These micro/nanostructures can efficiently facilitate dissipation of light energy into electricity and heat. Therefore, Black Silicon is becoming a new favourite in the fields of solar cell, photodetection, bio-imaging and security warning applications.



Precise and scalable nanomanufacturing of surfaces

Manish K. Tiwari,

UCL Mechanical Engineering, University College London

m.tiwari@ucl.ac.uk

An ability to engineer surfaces at scale with highly precise nanotexture can have dramatic positive impact on a number of energy applications. In this presentation, I will aim to clarify why and how precise such nanotextures must be, in order for these surfaces to have use in phase change applications which are often at the core of any energy technology.

In particular, I will focus on control of freezing and condensation processes, which have applications in energy anti-icing, energy storage and steam condensation among others. To exemplify the importance of this area of research, even a fractional increase in steam condensation efficiency can have a globally meaningful impact on the efficiency of steam power plants, which are by far the major producers of electricity.

I will show examples of nanoengineered surfaces which have a potential to address the precision and scalability needs of such applications, and also highlight the scientific and technological breakthroughs that are required for a meaningful exploitation of these surfaces in practice.

Synthesis and application of core-shell nanostructures of graphene-wrapped CdS nanoparticles and TiO_2 for photocatalytic H_2 generation

*Muhammad Zubair[1], Magnus Rønning[1] and Jia Yang[1],**

[1]Department of Chemical Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, NO-7491, Norway

** Corresponding Author: jia.yang@ntnu.no*

To overcome the issues related to low photocatalytic efficiency for H_2 generation due less light absorption by the semiconductor materials, cadmium sulphide (CdS) having a bandgap of ~2.4 eV is applied. The formation of core-shell nanostructures of CdS with TiO_2 has been shown to enhance the photocatalytic activity and stability for H_2 generation from water. The presence of TiO_2 over CdS nanoparticles increase the charge separation efficiency which eventually leads to enhanced activity and stability. Motivated to improve the photocatalytic activity of our previous core-shell nanostructure of CdS@TiO2 [1] and to utilize the conductor role of graphene (G), we report a new core-shell structure of CdS@G@TiO_2. The graphene layer present in between the CdS core and TiO_2 shell acts as a conductive layer, which promotes the charge separation efficiency (fig 1) even more than the CdS@TiO_2 nanostructure alone.

[1] M. Zubair, I.-H. Svenum, M. Rønning, J. Yang, Catal. Today. (2018). doi:10.1016/j.cattod.2018.10.070.

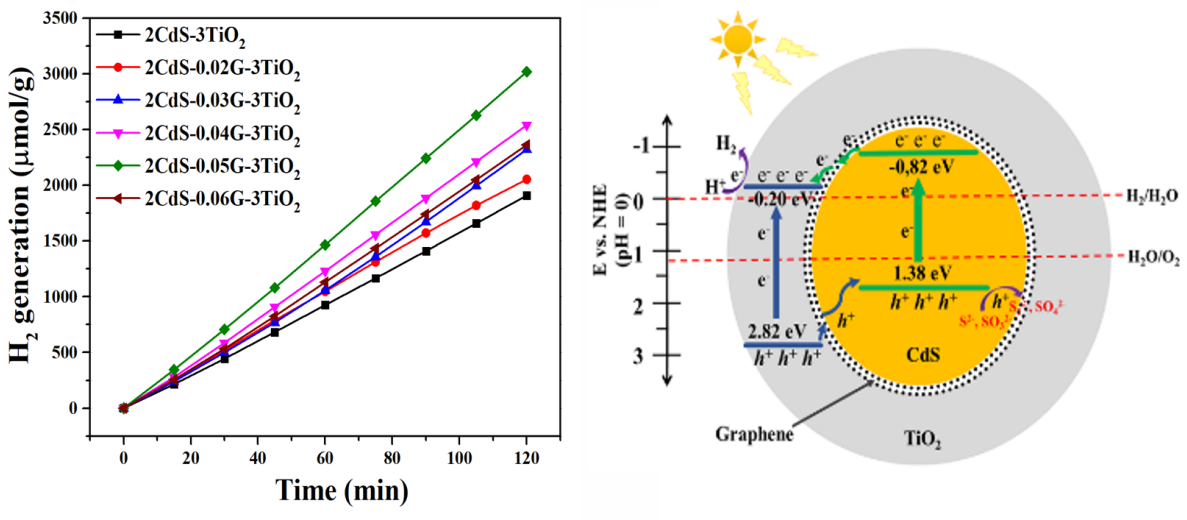


Fig. 1 Photocatalytic H_2 generation by utilizing CdS@G@TiO_2 samples and proposed reaction mechanism.

Ni-based nanoparticles as difunctional and efficient electrocatalysts for overall water electrolysis

*Fatemeh Poureshghi, Frode Seland and Svein Sunde**

Department of Materials Science and Engineering, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway;

svein.sunde@ntnu.no

Water electrolysis (WE) is the only feasible way of producing hydrogen on a large scale from water. Electrolysis of water comprises two half reactions, which take place at the two electrodes, the cathode and the anode. Molecular oxygen is produced on the anode and molecular hydrogen is produced on the cathode [1]. In this study, Ni and Ni_2P nanoparticles as an efficient electrocatalyst for overall electrochemical water splitting application have been synthesized by thermal reduction procedure consists the reaction of [$Ni(acac)_2$] with oleylamine (OA) and trioctylphosphine (TOP) reactants. This synthesis results in monodispersed nanoparticles around 12nm (Fig. 1) [2]. Synthesized Ni and Ni_2P nanoparticles can be directly utilized as electrocatalysts for both HER and OER in strong alkaline electrolyte, achieving a current density of 10 mA cm^{-2} with overpotentials at 0.114 V for HER and 0.32V for OER, respectively. Moreover, the effect of annealing of nanoparticles in three different atmospheres (Ar, H_2-Ar, air) and different temperatures were studied.

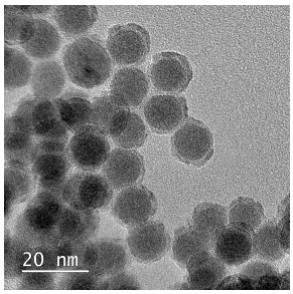


Figure 1. TEM image of as-synthesized Ni nanoparticles.

References

1. *Lu, F. et al. (2017). First-Row Transition Metal Based Catalysts for the Oxygen Evolution Reaction under Alkaline Conditions. Small, 13(45), 1–18.*
2. *Carenco, S., Boissière, C., Nicole, L., Sanchez, C., Le Floch, P., & Mézailles, N. (2010). Controlled design of Size-tunable monodisperse nickel nanoparticles. Chemistry of Materials, 22(4), 1340–1349.*

Nanocatalysis beyond Activity

De Chen

Department of Chemical Engineering, Norwegian University of

Science and Technology, N-7491, Trondheim, Norway

de.chen@ntnu.no

Scientists and engineers have long studied particle-size effects in catalysis, in particular aiming for increasing activity and reducing or replacing noble metals. The exciting opportunities and challenges of nanocatalysis in the chemical process beyond activity, in terms of remarkably improving selectivity and stability, will be discussed. This can be achieved only by precisely controlling the size, shape, spatial distribution, surface composition, and electronic structure, and thermal and chemical stability of the individual nanocomponents. We will discuss the strategy of engineering of the metal nanoparticle facets with particle size to manipulate the low- and high coordinate sites, bond length and electronic structures towards fine-tuning of not only the activity but also the selectivity and stability simultaneously. We will demonstrate excellent opportunities of nanocatalysts to manipulate the surface adsorption strength and reaction pathway to remarkably increase the resistance for coke formation and sintering, thus the catalyst lifetime [1-3].

References

[1] J. Zhu, M.-L. Yang, Y. Yu, Y.-A. Zhu, Z.-J. Sui, X.-G. Zhou, A. Holmen, D. Chen, ACS Catalysis, 2015, 5, 6310.

[2] J. Xie, J. Yang, A.I. Dugulan, A. Holmen, D. Chen, K.P. de Jong, M.J. Louwerse, ACS Catalysis, 2016, 6, 3147.

[3] W. Chen, J. Ji, X. Feng, X. Duan, G. Qian, P. Li, X. Zhou, D. Chen, W. Yuan, JACS 2014, 136, 16736.