LUND UNIVERSITY

NanoLund

ANNUAL REPORT | 2020

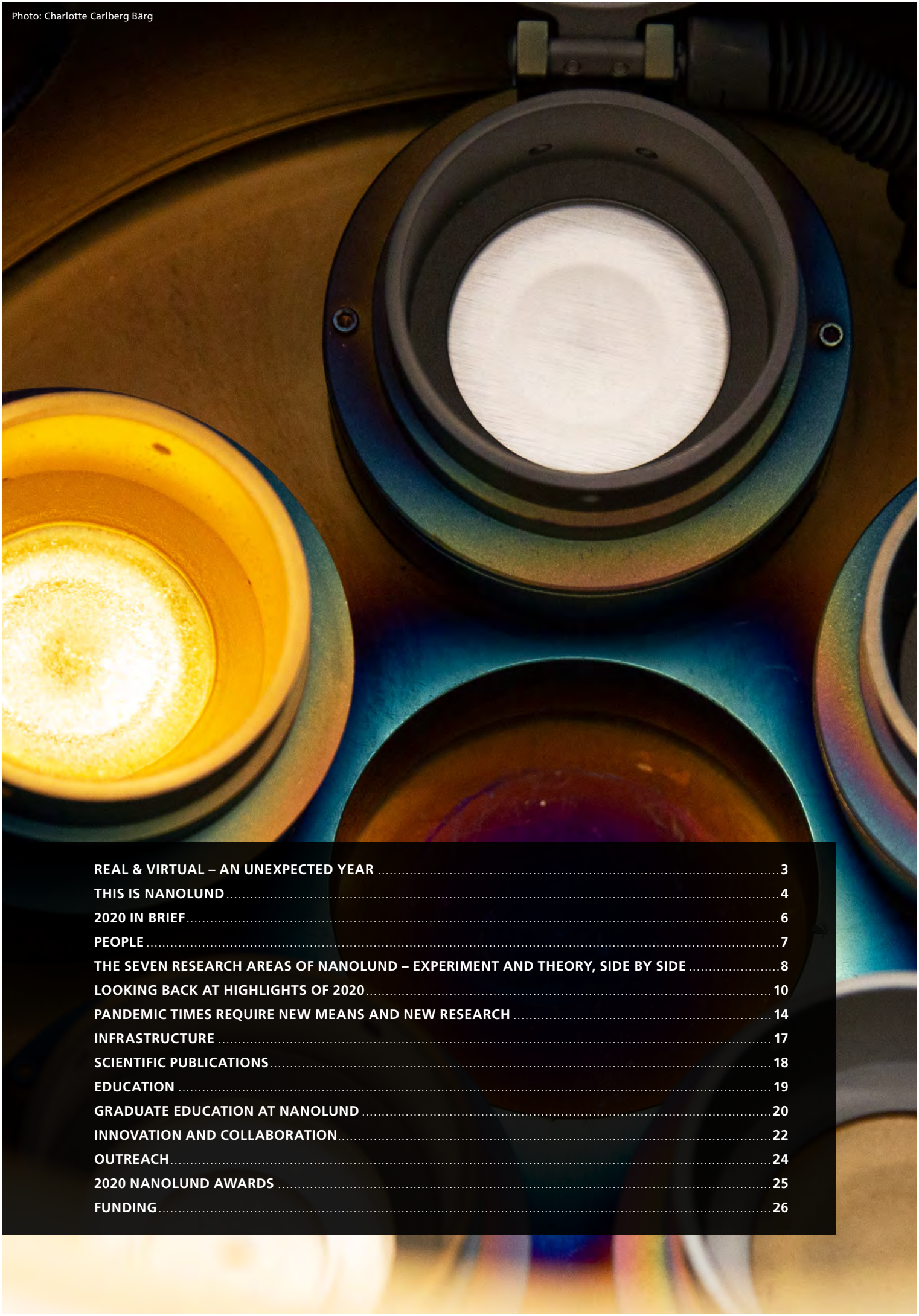


Photo: Charlotte Carlberg Bärg

Real & virtual – an unexpected year

2020 certainly did not turn out the way anyone imagined, presenting challenges for all of us. It has taught us a lot about working together using virtual meetings, remote experimentation and data sharing. However, it also demonstrated the limits of such technology; we need real-life meetings that can lead to new ideas, create enthusiasm and allow another level of openness. With this in mind, the importance of creating new great physical spaces such as in Science Village becomes even clearer. This year's events also show that controlling, understanding and sensing nanoscale objects (such as a virus) can be extremely important for our society. NanoLund researchers have contributed directly with knowledge and solutions, which reminds us that we can and should make an impact in society. Even in these difficult times, it has been gratifying to see how researchers in NanoLund created excellent fundamental and applied science and worked with companies, hospitals, and institutes. Our publications show a wide range of interesting topics from fundamental quantum phenomena, measuring and mimicking neural structures, extreme materials control and industrially relevant processes. Sustainability has been in focus in much research, dealing with the world's energy challenges as well as use for medical sensors and diagnostics with an impact for the many people.

In and around NanoLund, we have the luxury of an incredible suite of characterization tools. We have access to large facilities such as MAX IV and, in some years, ESS, and we have amazing in-situ microscopes, ultrafast lasers, and much more. This, coupled with strong theoretical efforts, makes it possible to build a better understanding of the world around us from the quantum level to living cells.

A crucial component in much of what we do is the ability to manipulate matter at the nano and atomic scale to create novel technologies. At the end of the day, this is how we impact the world. Lund Nano Lab is a key part of our efforts, and we are pleased that the Faculty of Engineering (LTH) decided to move forward to establish Nanolab Science Village at Brunnshög. Our Nano Lab is part of the national infrastructure Myfab, which was awarded significant funding from the Swedish research council after being rated outstanding. We will work for substantial additional funds to realize the new tools that will make Nanolab Science Village outstanding also in the future.

Our students have had a challenging year with limited access to experimental facilities and the everyday lively environment at the University. We are proud that they organized the International Nanoscience Student Conference, INASCON. What was supposed to be a conference in Lund had to be made digital at a rapid pace. Our students stepped up to this and created a great and engaging event, with 1 000 participants worldwide and featuring leading scientists in their fields, including Nobel laureate Ben Feringa.

Looking forward, Lund University has now established a strategy for 2020–2030 concerning the strategic research areas including NanoLund: "The complexity of today's societal challenges requires new solutions in which world-leading research brought together in collective efforts over subject and sector boundaries complements strong curiosity-driven research. The strategic research areas at Lund University are poised to tackle the most important issues of our times."

A warm thanks to all of our staff, students and partners, inside and outside the University, for your ongoing support, understanding and contributions through 2020. Finally, thanks to Heiner Linke, who stepped down as director of NanoLund at the end of the year to take on new challenges at Lund University, for his great contributions to our environment.

Photo: Kennet Ruona

Anders Mikkelsen,
Director NanoLund
since January 2021

This is NanoLund

NanoLund is the centre for research, education and innovation within nanoscience at Lund University, founded in 1988. It is a Strategic Research Area funded by the Swedish government.

NanoLund encompasses more than 50 research groups in the faculties of engineering, science and medicine and collaborators outside Lund University. It is Sweden's largest research environment in its field. The research topics range from materials science and quantum physics to applications in energy, electronics, photonics, personalized medicine and nanosafety.

SOCIETAL CHALLENGES WE AIM TO ADDRESS:

- **Enabling a sustainable society.** Paradigms and technologies for efficient harvesting and use of energy, and for nanomaterial-based products that are sustainable and safe from a life-cycle perspective.
- **A pathway to the future information society.** New physical concepts, smart materials, nanoscale devices, sensors and their heterogeneous integration to enable next-generation information technology.
- **Precision medicine.** Nano- and microstructures for biomedical research at the single-cell level and for fast point-of-care diagnostics, enabling targeted, individualized therapy.
- **Interaction with business and society.** Collaborate with the private and public sectors both locally and internationally. Jointly we can address sustainable development goals, help solve societal challenges, and create new industry.

WE WORK WITH THE FOLLOWING SPECIFIC STRATEGIC AIMS:

- **Building and understanding devices with atom-level control.** To realize three-dimensional nanostructures, devices and systems with atom-level control and gain a deep understanding of their physical, chemical, and/or biological interactions by modelling and characterizing them at all relevant length- and time scales.
- **Pioneering science.** To make fundamental scientific discoveries that increase our understanding of the world. It forms the basis for finding new paradigms and device concepts, for example, based on quantum phenomena or fluctuations in small systems.
- **Nanotechnology applications.** To invent and engineer devices with enhanced performance and new capabilities for energy, ICT, sensing and diagnostics, building on the safe use of advanced nanotechnology and a deep understanding of the underlying science.
- **A Great Place to do Nanoscience.** To be an international, highly visible nanoscience centre that offers exceptional scientific opportunities, training, and career development. To create state-of-the-art clean room facilities and space designed for close interactions within NanoLund, with scientists at Lund Laser Centre, MAX IV and ESS, and with students at all levels in Science Village.
- **Interaction with society.** To be a leader in building an ecosystem that integrates education, interdisciplinary research, R&D, and private-public collaboration to exchange ideas and promote innovation that improves our society.

OUR VISION: TO BE AT THE FOREFRONT OF NANOSCIENCE

To be a world-leading research centre that uses the unique opportunities offered by nanoscience to advance fundamental science and to address societal challenges.

OUR MISSION: TO BE A GREAT PLACE TO DO NANOSCIENCE FOR THE NANOTECHNOLOGY OF THE FUTURE

To bring together the most creative scientists, students and industry professionals in an interdisciplinary research environment to do cutting-edge research on the materials science, physics, chemistry and safety of designed functional nanostructures, enabling important fundamental science and nanotechnology for the future.

NANOLUND SCIENTIFIC ADVISORY BOARD


Stephen Goodnick


Chi-Chang Kao

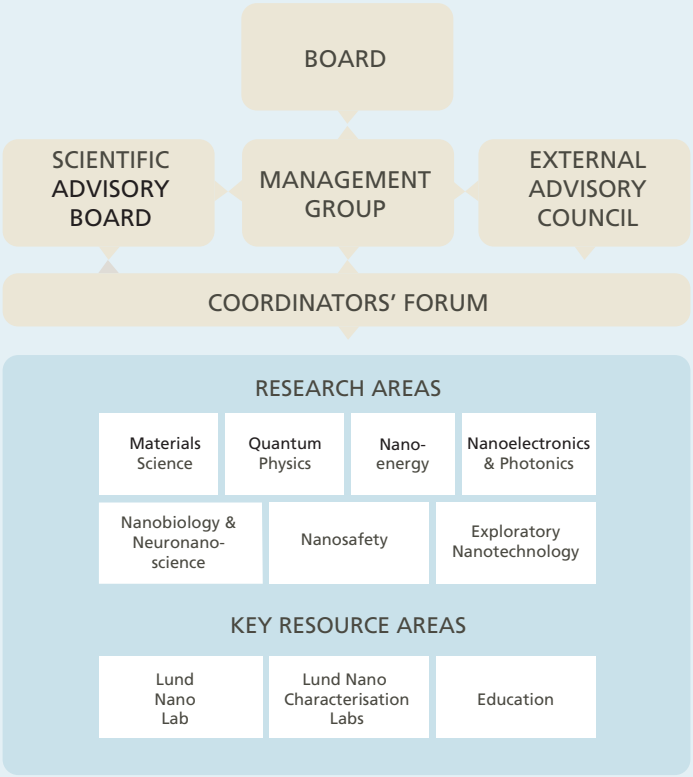

Chris Palmstrøm


Heike Riel


Friedrich Simmel


Ulla Vogel


Martin Wolf



NanoLund is headed by a Board, which defines strategy and makes formal decisions. The centre is advised by an international Scientific Advisory Board and an External Advisory Council with members from society, academia and industry. We are organized into seven research areas and three key resource areas that enable and complement our scientific work.

NANOLUND BOARD 2020:
Viktor Öwall (Chair), *Dean, LTH* | Kimberly Dick Thelander, *Faculty of Engineering* | Peter Honeth, *Chair MAX IV Laboratory Board* | Thomas Hønger Callisen, *SenseUnlimited* | Erik Lind, *Faculty of Engineering* | Heiner Linke, *Director, NanoLund* | Sara Linse, *Science faculty* | Camilla Modéer, *IVA* | Kristian Pietras, *Medical Faculty* | Oskar Ström, *student representative* | Karolis Sulinskas, *student representative* | Marcus Hothar, *deputy student representative* | Ivan Unksov, *deputy student representative*

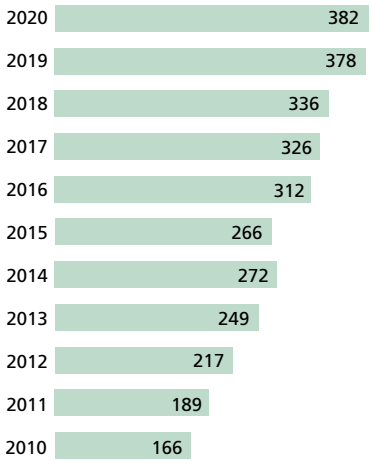
NANOLUND MANAGEMENT GROUP 2020:
Heiner Linke, *Director* | Anders Mikkelsen, *Vice-Director* | Anneli Löfgren, *Co-Director* | Martin Leijnse | Tommy Nylander | Christelle Prinz | Ivan Scheblykin

SCIENTIFIC ADVISORY BOARD 2020:
Stephen Goodnick, *Arizona State University* | Chi-Chang Kao, *SLAC/Stanford University* | Chris Palmstrøm, *UC Santa Barbara* | Heike Riel, *IBM Research, Zürich* | Friedrich Simmel, *TU München* | Ulla Vogel, *NFA, Copenhagen* | Martin Wolf, *Fritz Haber Institute of the Max Planck Society, Berlin*

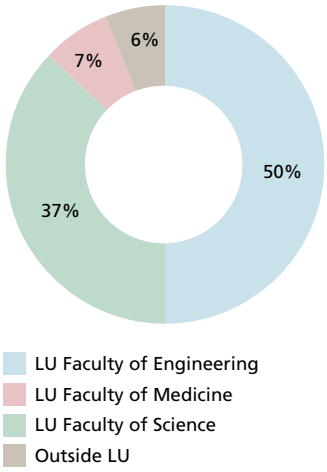
EXTERNAL ADVISORY COUNCIL 2020:
Camilla Modéer (Chair), *IVA* | Ola Asplund, *IF Metall* | Lars Börjesson, *Chalmers University* | Peter Honeth, *Chair MAX IV Laboratory Board* | Per Krokstäde, *IKEA* | Daniel Kronmann, *Region Skåne* | Anna Stenstam, *CR Competence*

2020 in brief

Staff 2010–2020



Faculty affiliation



NanoLund includes

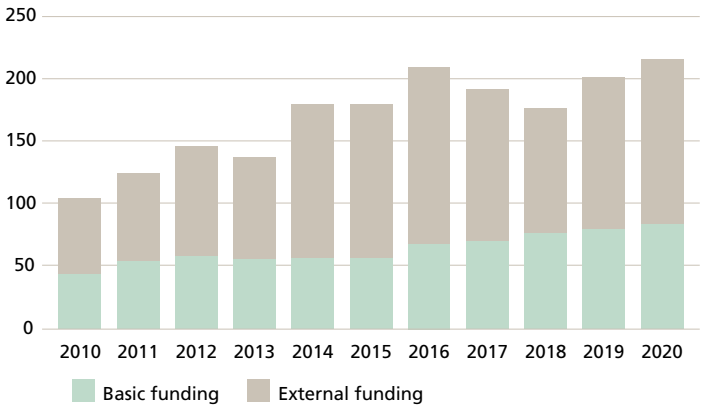
13	recipients of ERC awards
3	Wallenberg Scholars
3	holders of VR Distinguished Professor grants
9	ongoing EU-projects
11	ongoing Wallenberg projects and VR Research environment grants

Current numbers

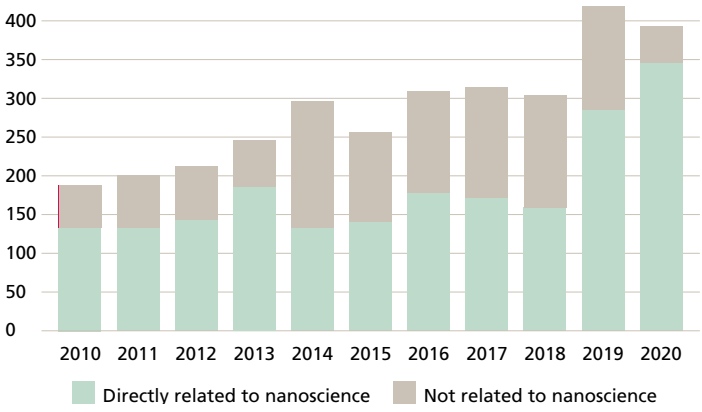
MSEK funding	216
% from external funding sources	61
Average impact factor	6.5
Contributing LU divisions	26
NanoLund staff	382
% women of NanoLund staff	31
Faculty Members	55
PhD-students	145
Undergraduate student members	> 90

Trends

Funding over time (MSEK)



Total number of publications



History

2019	Kick-off for our industry- and stake-holder network Nanotech Now
2016	NanoLund forms a vision and starts strategic work for establishment at Science Village
2015	The Strategic Research Area becomes NanoLund, the Centre for Nanoscience at Lund University
2009	Strategic Research Area selected by the Swedish Government
2007	Inauguration of Lund Nano Lab
2003	Starting the new education program Engineering Nanoscience (BSc and MSc)
1995	SSF funds nmC with several significant grants until 2012
1988	The Nanometer Structure Consortium (nmC) is initiated

People

PERSONNEL & MEMBERSHIP

In 2020, 384 persons were involved in NanoLund as PI, researcher, PhD-student or technical and administrative staff. The number of Faculty Members and Affiliated Faculty Members were 55 and 39, respectively. Since NanoLund became a Strategic Research Area in 2009, the number of postdocs and PhD students has almost tripled. In contrast, the number of Faculty Members has remained approximately constant, an indication that the NanoLund research groups are thriving. The average annual level of engagement in NanoLund was 64% in 2020, corresponding to 244 full-time equivalents. In the past years, we have seen an increased interest in collaborating and becoming a part of the research environment, reflected by an increase in the number of Affiliated Faculty Members.

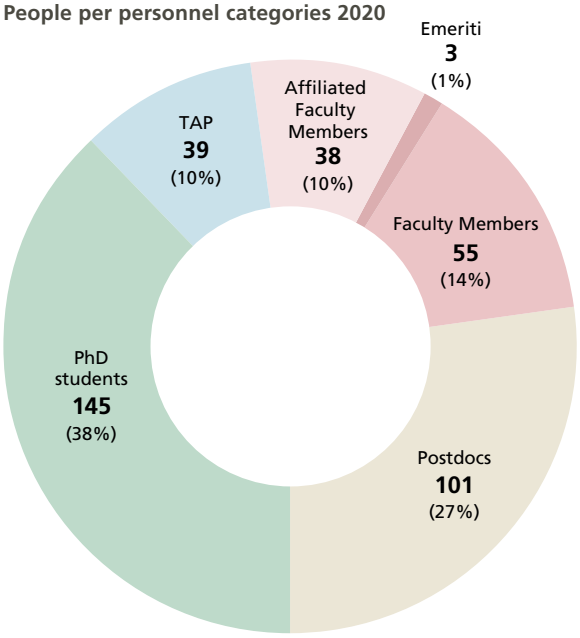
Gender balance 2020

NanoLund strives for gender balance and for being a diverse and inclusive workplace. Overall, 31% of the total staff at NanoLund are women.

Current statistics for academic positions are:

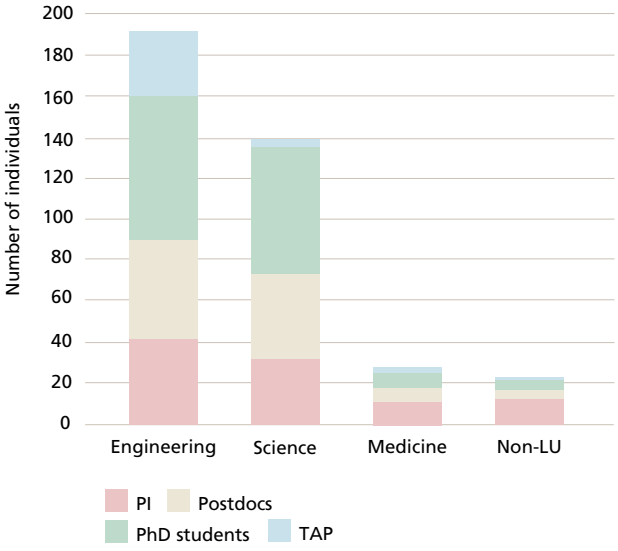
PIs:	22% women	78% men
Postdocs:	22% women	78% men
PhD students:	39% women	61% men

People per personnel categories 2020

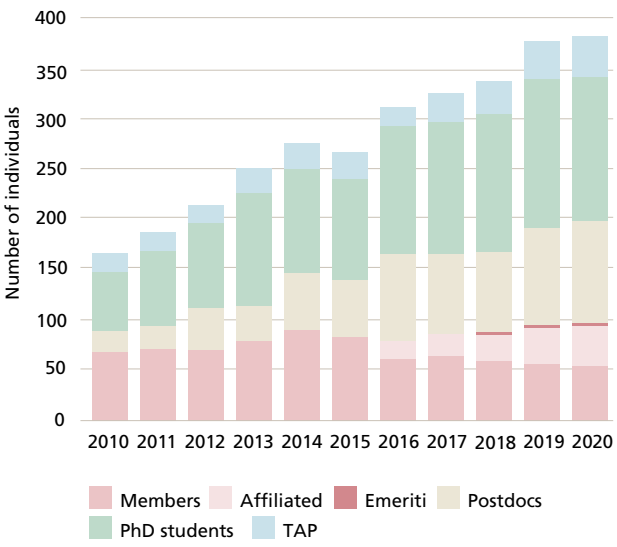


We will take further actions to improve the gender balance at all levels over the following years as we work with faculties and departments on even better and more diverse recruitment. It is promising that 44% of the students entering the undergraduate programme in nanoscience were women this year, the highest ever.

NanoLund people by faculty in 2020



Personnel trends 2010–2020



The seven research areas of NanoLund – experiment and theory, side by side

MATERIALS SCIENCE

Materials science relates the atomic structure to the properties of a material. It also governs when and how nanostructures form and what structure to expect. Even very small changes in formation conditions can cause dramatic changes in the resulting nanostructure, and the challenge is to detect and control these. Our key expertise is in solid-phase nanostructures fabricated from the vapour phase, especially semiconductor nanowires and metal nanoparticles. To ensure development of high-quality nanostructures, experiment is combined with theory and simulations to warrant a fundamental understanding of the material formation process. We use advanced techniques to characterize the nanostructures and continuously develop new processes and applications.

QUANTUM PHYSICS

In nanostructured systems, pronounced quantum behaviour gives rise to exciting new fundamental physics as well as potential applications. We develop the theoretical tools to better describe such quantum phenomena, work to experimentally observe them, and then identify advanced device concepts where quantum effects enable better performance. The superposition of states and entanglement open completely new perspectives for sensing and communication technology. Quantum thermodynamics develop new paradigms for energy conversion and quantum devices at the nanoscale, where thermal and quantum fluctuations may conspire to profoundly alter the physical properties and lead to fundamentally new physics.

NANOENERGY

The need for clean and sustainable energy is one of our greatest global challenges. We aim to harness the unique electronic, photonic and structural properties of highly controlled nanomaterials to harvest and convert energy with higher efficiency and less material use than currently possible. If we, for example, could convert a small fraction of the solar energy to useful energy forms, our future energy supply would be secured. At the nanoscale, electrons and atoms perform random thermal motion and can be subject to quantum effects. Can we use the kinetic energy of electrons to do useful work? Can quantum phenomena make energy conversion more efficient? We combine experiment and theory to explore the fundamentals of power generation using heat and light, as well as information.

NANOELECTRONICS AND PHOTONICS

Electronic and photonic devices are at the heart of the modern information society. With advanced, controlled nanostructures, we demonstrate novel devices as well as improving and refining conventional devices. Smaller device geometries lead to higher operation frequencies, larger signal gain and better packing density. We explore transistors close to the atomistic limit to implement high-performance electronics devices for radiofrequency and computation. At the nanoscale, light interacts with matter in novel ways – and we investigate both how to understand the nanostructures on a quantum level as well as how to control light using nanostructures. Is it possible to improve optical devices using nanostructures? Can we use light to "see" exactly how nanostructures function?

NANOBIOLOGY AND NEURONANOSCIENCE

By manipulating and controlling individual molecules and cells at the nano and micro scales, we gain a mechanistic and quantitative understanding of fundamental biological processes. Specifically, understanding nanostructures and their interactions with cells with respect to behaviour, physiology and mechanics, forms the basis for novel nanoscale devices addressing urgent needs in biology and medicine. Implantable and biocompatible nanostructured neural interfaces will allow us to study neurocommunication in conscious individuals, helping us understand learning and information processing. Mimicking fundamental biological mechanisms opens up for applications ranging from diagnostics to novel types of computing.

NANOSAFETY

Nanostructures have new properties often not present at the macroscale. Exploring the fundamental connections between nanostructure properties and human and environmental toxicology, as well as of emissions and exposure in all stages of the lifecycle of a nanomaterial, helps to provide the tools needed for a safer design development and production of novel materials. Emissions and exposures are studied with state-of-the-art instruments both in workplace environments and in controlled laboratory settings. The toxicological effects are studied on all levels: single cells, organisms, and ecosystems using various in-vitro, ex-vivo, and in-vivo methods. Safe production and use of nanomaterials require knowledge

of nano-related toxicity as well as effective risk management ranging from legislative and regulative levels down to hands-on work processes.

EXPLORATORY NANOTECHNOLOGY

This testing ground for innovative nanotechnology explores novel methods of nanofabrication with atomic layer control and evaluates their strategic importance for NanoLund. We investigate ultra-high-resolution lithographic and patterning techniques, study possible ways to combine heterogeneous materials and devices in 3D and explore novel properties that emerge due to the nanostructuring and long-range order of materials. Good control over the interfaces in nanostructures and nanodevices ensures their superior electrical, optical and other properties. The combination of materials, structures and devices that traditionally do not go together can open a wide range of scientific and technical opportunities. Combining advanced materials of high quality can enable new physics and breakthroughs in system performance.

Photo: Kennet Ruona

Christina Isaxon, Coordinator Nanosafety, Senior lecturer Ergonomics and Aerosol Technology.

Looking back at highlights of 2020

GIVING ALFA LAVAL INSIGHTS

Together with Alfa Laval and MAX IV, NanoLund researchers Filip Lenrick and Anders Mikkelsen have studied and imaged stainless steel at an extreme atomic scale. The focus of the experiments was to get valuable insights on the nanometre-thin oxide layer protecting stainless steel from corrosion and use the outcome from the experiment in Alfa Laval's future product development.

The experiment was partly funded by Sweden's Innovation Agency, Vinnova, and the Swedish Foundation for Strategic Research, SSF.

EXPOSURE TO NANOPARTICLES STUDIED

What are the potential health effects of the new, promising and fast method to produce nanowires by aerotaxy? A significant part of the potential for exposure occurs not during the actual manufacturing but during the cleaning and maintenance procedures, shows this study.

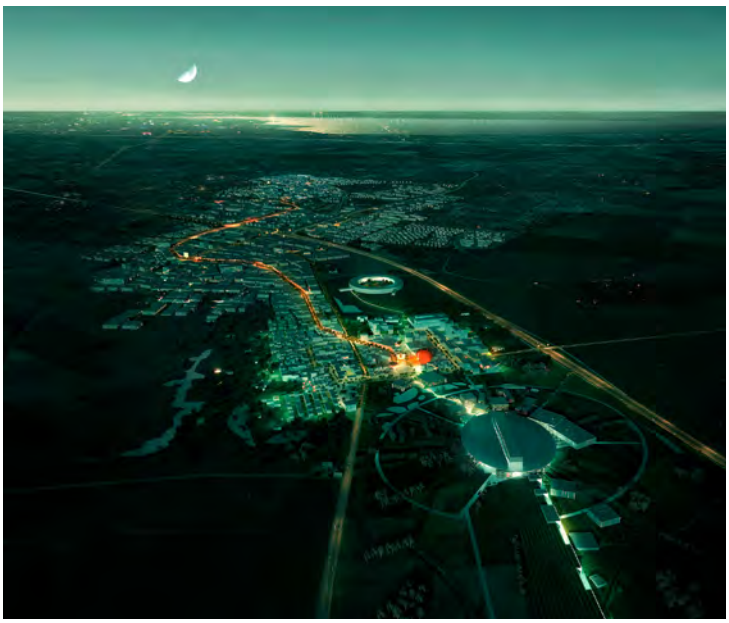
C. Isaxon et al

Annals of Work Exposures and Health, Vol 64, Issue 1, Jan 2020

https://doi.org/10.1093/annweh/wxz088

GRANT FOR GREENER CATALYSTS

Maria Messing has received a Future Research Leaders grant from the Swedish Foundation for Strategic Research, SSF. In the research program Nano Design meets Organic Chemistry for Greener Catalysts, she combines nanoscale processing and organic chemistry to develop new types of rationally designed catalysis aiming for more sustainable production. SSF supports scientifically and pedagogically eminent young researchers, showing potential for leadership and ambition to later take responsibility for complete academic environments in academia or industry.



COBE / Science Village

Important step towards new Nanolab at Science Village

The process of establishing a Nanolab Science Village in Brunnshög moved further due to decisions of the Board of the Faculty of Engineering, LTH. The laboratory is part of the first stage of Lund University's establishment in Science Village. After ESS and MAX IV, Nanolab Science Village will be the third major research facility in the northeastern parts of Lund and is part of the national research infrastructure Myfab. Whereas MAX IV and ESS focus on materials analysis, Nanolab Science Village will become the first infrastructure in Science Village to make advanced new materials available. The construction is estimated to cost about SEK 600 million, including equipment. The ambition is to complete it by 2025. Procurement of a landlord is prepared and will be followed by detailed negotiation of the building's design in relation to the cost. The funding strategy to promote the opportunities of nanotechnology to find sustainable solutions to benefit the planet and humanity includes contributions from both government and private sources and, NanoLund and the University work tirelessly to secure financing for both building, equipment and operations.

"This is a strategic decision and, in addition, the first step to establishing Lund University at Brunnshög. Someone needs to lead to get the process started, but we will need to work on many fronts to secure the financing", says Viktor Öwall, Dean of LTH, until December 2020.

Both the Faculty of Engineering and the Faculty of Science have decided to establish parts of their research and education activities at Brunnshög.

TOWARDS MORE SUSTAINABLE ENERGY SYSTEMS

The Swedish Energy Agency has, partly with the assistance of Swedish Research Council, given grants for sustainable energy system research to NanoLund researchers Kenneth Wärnmark, Knut Deppert, Magnus Borgström, Lars Samuelson, Tönu Pullerits and Rasmus Westerström. The projects involve iron-based materials that enable the production of solar fuel on a large scale, nanowire-based solar cells, ultra-efficient RGB lighting based on nanowire technology, nanowire-based LEDs with multiple wavelengths in the visible range, nanowire-perovskite tandem solar cells, and stable, highly efficient solar cells from 2D perovskite.

"The number of applications was record high, and we are happy that so many good projects sought financing within the call Curiosity-driven research for a sustainable energy system", says Fredrik Brändström, program manager at the Swedish Energy Agency.

Protein motor research project gets ERC Synergy Grant

Building engines – out of proteins. That is the aim of a research project, with Heiner Linke at NanoLund as the corresponding principal investigator who received an EUR 10 million ERC Synergy Grant.

Photo: Kennet Ruona

"We can certainly assume that there is a reason why evolution chose proteins as the main building block for life", says Heiner Linke. In the project called ArtMotor – Artificial Motor Proteins: toward a designed, autonomous protein motor built from non-motor parts, Heiner Linke and his collaborators aim to understand what happens when proteins generate movement from chemical fuel.

MIMICKING THE NAVIGATION OF THE INSECT BRAIN

What is it about the insect brain that allows them to navigate so easily? Could we copy that function? A step in this direction has now been taken by a group of scientists in a project combining the fields of biology, physics, nanoscience and informatics.

"You could say that we have been using the biologists' results as a design to construct a very simple and energy-efficient way of navigating by imitating the insect brain's function for that area. There are many possible uses for this type of technology. Small drones, robot vacuum cleaners or other things that need to navigate with a very limited energy supply," says David Winge.

D. O. Winge et al
ACS Photonics 2020, 7, 10, 2787–2798
https://doi.org/10.1021/acsphotonics.0c01003

ANNE L'HUILLIER SCORES RARE GRANT HAT-TRICK

For the third time, Anne l'Huillier, professor of Atomic Physics and NanoLund affiliated member, has been awarded the prestigious European Research Council's (ERC) Advanced Grant. With the granted project Quantum Physics with Attosecond Pulses, l'Huillier and colleagues plan to use laser technology to create ultra-short light pulses to study the motion of electrons within atoms and molecules. Their work will provide a new fundamental understanding of the dynamics inside atoms, taking a step deeper into the world of quantum mechanics.

Photo: Magnus Bergström, the Wallenberg Foundations

ERC STARTING GRANT FOR NEW X-RAY MICROSCOPE TECHNIQUE

When rotating is not required, less damage is done to samples studied in X-ray microscopes. Pablo Villanueva Perez from NanoLund and Synchrotron Radiation Physics will develop this technique with a new X-ray microscope in the project Probing MHz processes in 3D with X-ray microscopy, for which he has received an ERC Starting Grant. "I will use the new microscope to study fundamental processes in cellulose, which is a renewable material. My hope, in the long run, is to produce an environmentally friendly material that can replace plastic", says Pablo Villanueva Perez.

Photo: Johan Joelsson

Photo: Kennet Ruona

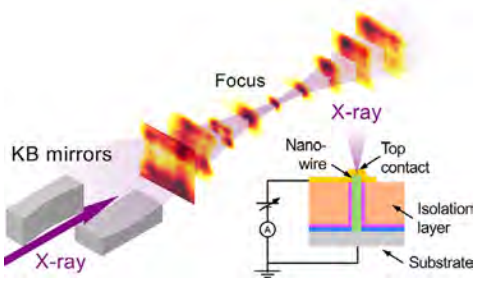
IMAGING THE X-RAY FOCUS OF NANOMAX WITH A SINGLE NANOWIRE

A team of researchers from Lund University has imaged the beam focus at the hard X-ray nanoprobe NanoMAX using a single nanowire as the detector. The result is an unprecedented ultrahigh-resolution 3D image of the 88-nanometre diameter focus revealing fine details of the beam.

"A basic way of describing an X-ray experiment is that a well-defined beam illuminates a sample and interacts with it. Downstream from the sample, we place devices that can detect any signal that comes out on the other side. That may be a weaker X-ray beam, a scattered X-ray beam, electrons emitted by the sample, and so on. By comparing what we send in towards the sample and what comes out, we can learn about, for example, the structure, chemical or magnetic properties of the sample", Jesper Walllentin, associate professor at the division of Synchrotron Radiation Research, said.

The nanowire device is fabricated in Lund Nano Lab (Myfab Lund) and then used as an X-ray detector and involves Jesper Wallentin's ERC grant.

L. Chayanun et al
Nano Letters 2020, 20, 11, 8326–8331
https://doi.org/10.1021/acs.nanolett.0c03477



Research and industry borderland nestor was named Honorary Doctor

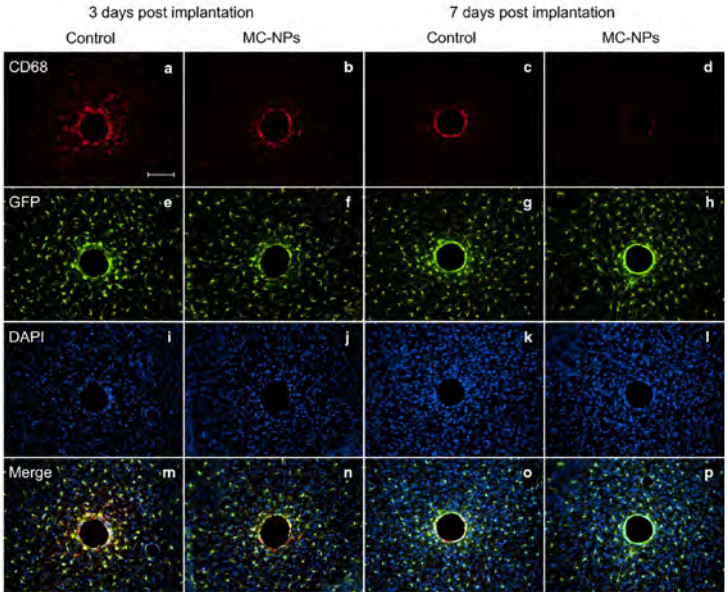
Dr Camilla Modéer, chair of NanoLund's External Advisory Council and member of the NanoLund Board was in 2020 selected by The Faculty of Engineering at Lund University for an honorary doctorate. As a member of The Royal Swedish Academy of Engineering Sciences (IVA) and the first general secretary of Vetenskap och Allmänhet (Public and Science), she has extensive experience working in the borderland between research and industry.

Camilla Modéer gave her honorary doctorate lecture as a part of Nano Lund's Annual Meeting 2020. The lecture with the title "Excellence versus purpose – trade-off or synergy?" argued that to achieve the best results, attitudes and structures in academia and industry must change. She maintained in her lecture that the pursuit of scientific excellence and the utilization of research results strengthen one another. The universities need to improve scientists' incentives to collaborate with industry and civil society.

OBSERVING THE EMERGENCE OF A QUANTUM PHASE TRANSITION SHELL BY SHELL

By studying cold atoms, researchers have in a unique way been able to observe a precursor to a quantum phase transition and thereby study physical processes that can be compared to the Higgs mechanism. The discovery can, among other things, provide more knowledge about quantum mechanical processes that are similar to the processes in which matter changes its state from gas, liquid, or solid form into another state. Understanding the emergence of collective phenomena and the thermodynamic limit, particle by particle is important atomic as well as solid state systems.

L. Bayha et al
Nature 587, 583–587(2020)
https://doi.org/10.1038/s41586-020-2936-y



Holmkvist et al in Nanobiotechnology. 2020; 18:27.

Immunofluorescent images of activated microglia and neuronal response inside the mice brain, after implantation with gelatin-coated needles.

NEW METHOD SLOWLY RELEASING DRUGS LOCALLY IN THE BRAIN

By releasing the drug locally, the rest of the body does not have to be affected. The drug is encapsulated in nanoparticles and delivered to the brain tissue via flexible electrodes.

"Using nanoparticles enables a local release of medication exactly where you want it to be released. These are very low doses, a million times lower than what would be administered orally. No refill of the drug is required as it is released over such a long time", says Jens Schouenborg. He believes the method could also be relevant for delivering medication locally to other soft tissues, such as local treatment of cancer.

A.D. Holmkvist et al

J Nanobiotechnol 18, 27 (2020).

https://doi.org/10.1186/s12951-020-0585-9

NANOSTRAWS USED TO DELIVER BIOMOLECULES TO HUMAN HEMATOPOIETIC STEM CELLS

Researchers from the strategic research areas NanoLund and StemTherapy have developed a promising new method for delivering biomolecules into human blood stem cells using nanotechnology. With little to no detrimental effects on target cells, this novel approach has great potential for research and clinical applications.

"The surprisingly gentle nature of this method encourages us to explore practical applications of nanostraws," concludes Martin Hjort. "Moving forward, we are now using this technology to deliver gene-editing agents, such as CRISPR-Cas9, which can potentially be used to correct disease-causing genetic mutations."

L. Schmiderer et al

Proceedings of the National Academy of Sciences Sep 2020, 117 (35) 21267-21273

https://doi.org/10.1073/pnas.2001367117

INDEPENDENT CONTROL OF NUCLEATION AND LAYER GROWTH IN NANOWIRES

Understanding the mechanistic processes controlling nucleation and crystal growth is key to designing materials with desired properties. Control of the crystallization is central to developing nanomaterials with atomic precision to meet the demands of novel electronic and quantum technologies. Two sequential steps in the crystallization process – nucleation and layer growth – can occur on similar time scales and can be controlled independently.

C. B. Maliakkal et al

ACS Nano 2020, 14, 4, 3868–3875

https://doi.org/10.1021/acsnano.9b09816

STRAIN MAPPING INSIDE A NANOWIRE TRANSISTOR USING SCANNING X-RAY NANODIFFRACTION

A reliable and time-efficient benchmarking of strain in embedded nanoscale devices without damaging the sample allow the rational use of processing layers to control, for example, the channel mobility in semiconductors. The method used in the study can be applied to a multitude of metrology studies of functional crystalline elements within complete devices.

D. Dzhigaev et al

Nanoscale, 2020, 12, 14487-14493

https://doi.org/10.1039/D0NR02260H

REACHING THE ULTIMATE ENERGY RESOLUTION OF A QUANTUM DETECTOR

This study reaches a limit of fundamental equilibrium fluctuations of temperature in a nanoscale electron calorimeter, exchanging energy with the phonon bath at very low temperatures. The approach allows non-invasive and highly efficient measurement of energy transport in superconducting quantum circuits in the microwave regime, opening the way to observe quantum jumps, detecting their energy to tackle central questions in quantum thermodynamics.

B. Karimi et al

Nature Communications 11, 367 (2020)

https://doi.org/10.1038/s41467-019-14247-2

Photo: Kennet Ruona

Pandemic times require new means and new research

A YEAR ON-LINE. We kept calm and carried on – but with precautions and a digital twist. 2020 was not an ordinary year. Due to the pandemic, NanoLund, as everyone else, has found ways to continue forward despite ever-changing restrictions. Remote access to several instruments has been developed, ways to perform experiments from a distance were elaborated, teaching and lab supervision moved on-line, as did thesis defences. Support staff have been working shifts to ensure access to research facilities. Several research groups started working on proposals for funding, and many NanoLund researchers directed focus towards the SARS-CoV-2 virus. Overall, we have adapted to the situation and gotten used to the digital discussions. But the spontaneous meetings have not been that many nowadays, and we do miss them a lot.

NanoLund had to organize not only the research and teaching digitally, but also its Annual Meeting in a completely new way. Only 50 of the participants were on-site at AF-borgen, and a lot of space was kept between people at all times during talks and mingling. All other participants followed the meeting on-line – and, as an unexpected benefit, among those were some who under normal circumstances would not have been able to participate.

Although under different circumstances, NanoLund scientist have in 2020 continued to present our scientific work in nanoscience worldwide. A total of 35 invited talks, of which 5 were keynote or plenary talks, were presented.

FINDING FASTER METHODS FOR DETECTING VIRUS

To detect a virus or other infectious agents in cell samples, medical and clinical laboratories usually employ the polymerase chain reaction (PCR). It is a widely used method in biomedical research to make copies of DNA or RNA from a tiny sample, amplifying it to a large enough amount to study in detail. The problem is: this technique takes time.

NanoLund scientists within the research environment "Genes&Wires" aim to detect DNA or RNA in samples without PCR.

"The goal is to be able to read off for example virus RNA directly, instead of having to wait for several hours, which is the case when you involve the PCR", says Heiner Linke, professor at Solid State Physics and director of NanoLund until December 2020.

AIR SAMPLES FROM PATIENT ROOMS ANALYZED

Many questions concerning the SARS-CoV-2 virus and infection prevention need to be answered as soon as possible. Jakob Löndahl, associate professor in aerosol technology at Lund University and faculty member of NanoLund has during the year worked on analyzing air samples from patient rooms at Lund University hospital trying to increase the understanding of the presence of SARS-CoV-2 in the air. If certain situations can be linked to increased concentrations of airborne virus, it may play an important role in the design of guidelines and hygiene routines for healthcare professionals in contact with Covid-19 patients.

EXHALED RESPIRATORY PARTICLES DURING SINGING AND TALKING

Aerosol researchers Jakob Löndahl and Malin Alsved have studied the amount of particles we actually emit when we sing, – and by extension – if we contribute to the increased spread of covid-19 by singing.

Singing generated more respiratory aerosol particles and droplets than talking. Exhaled aerosol particles and droplets increased with song loudness. The data also indicated that emissions might increase at high pitch. Wearing an ordinary surgical face mask reduced the amount of measured exhaled aerosol particles and droplets to levels comparable with normal talking. Based on the results in the study, singing in groups is likely to be an activity at risk of transmitting infection if not appropriate control and prevention measures are applied, such as distancing, hygiene, ventilation and shielding.

M. Alsved et al

Aerosol Science and Technology, 54:11, 1245-1248,

https://doi.org/10.1080/02786826.2020.1812502

EFFICIENT, RAPID ONE-STEP COVID DETECTION

Christelle Prinz received ERC Funding of € 150.000 for her project *One-step switchable fluorescent probe assay for direct virus detection (1-SWITCH).*

The project will build on her previous findings and apply a method developed as part of research funded by her earlier ERC Consolidator Grant, which could help enable a single-step detection of virus. Her team will use low-cost reagents technology to develop more affordable tests than those currently available on the market. Their goal is to develop rapid, one-step tests with efficiency superior to the antigen tests and comparable to PCR tests.

"There is a great need for testing even after the vaccination has started. For example, home care staff or others who work with the elderly can test themselves quickly and easily before they go out on a work shift", says Christelle Prinz.

Infrastructure

LUND NANO LAB – MYFAB LUND

Lund Nano Lab (LNL) is an open research facility available to academic research groups, start-ups and company users. It constitutes one node of Myfab, the national research infrastructure for micro and nanofabrication. Our cleanroom facility is equipped with state-of-the-art semiconductor processing and metrology equipment that is continuously updated. It is a central resource for nanoscience and nantechnology, and provides support to research groups in strategically important fields of materials science, nanotechnology, information and communication technologies (ICT), life science and quantum technology. Another important task is to educate students enrolled at Lund University. We also participate in outreach activities for the local community and society.

The decision by LTH in early 2020 to move on in the process of establishing a new Nanolab at Science Village was met with great enthusiasm since the user base of the lab, which was designed originally for 40-50 users, has tripled to 140 users since 2007. The new Nanolab will be the third major research facility at Brunnshög alongside MAX IV and ESS. Whereas MAX IV and ESS focus on materials analysis, Nanolab Science Village will become the first infrastructure in Science Village to make advanced new materials available. Therefore the planning and preparations for the new Nanolab at Science Village have been a major, exciting and important task during 2020.

Maintaining and improving the equipment inventory at Lund Nano Lab via grant applications has been a critical focus in the preceding years and will continue to be so as we prepare for the new Nanolab. In total, the funding strategy includes contributions from both government and private sources, and NanoLund and the University work tirelessly to secure financing for both building, equipment and operations.

In 2020, extraordinary efforts were made to ensure that the lab remained open 24/7 throughout the Covid-19 pandemic for all users to conduct their important research and educational programs. This was only possible with the dedicated support from highly educated lab personnel, which includes 15 persons, four of which have a PhD-degree. The lab staff maintain the equipment and facility, provide cleanroom and safety education for new lab users and provide advice and guidance regarding processing and characterization.

The number of hours booked on tools in 2020 was reduced by about 20% compared to 2019 but still stood at an impressive 39 000 hours (equivalent to 22 full-time employees working full-time). The reduction of booked hours was due in part to users delaying or deferring their lab work, but also due to unscheduled downtime of some equipment that was affected by the availability of service engineers to travel to Lund from other countries.

Statistics LNL 2020

Users with access	**300**
Active users	**136**
New users	**30**
Research groups	**31**
Research group users	**119**
Companies	**7**
Company users	**15**
Institutes	**1**
Institute users	**2**
Booked hours	**39 000**

Photo: Charlotte Carlberg Bärg

LUND NANO CHARACTERIZATION LABS

NanoLund possesses an extensive range of cutting-edge characterization instruments and techniques ranging from microscopes capable of single-atom imaging to ultrafast spectroscopy laboratories capable of tracking processes on a femtosecond time scale. These characterization laboratories are distributed all across Lund University.

Researchers at NanoLund are carrying out ground-breaking methodological developments in areas such as electrical and optical nano-characterization, multidimensional laser spectroscopy, scanning probe microscopy, transmission electron microscopy, synchrotron-based imaging, spectroscopy and scattering, nanosafety, biocompatible nanoelectrodes, as well as many-body and transport theory. Two cornerstones of our success are these new cutting-edge characterization methods originally developed in Lund and the enthusiastic and free sharing of facilities and expertise. To strengthen and coordinate these efforts, Lund Nano Characterization Labs was created in 2009.

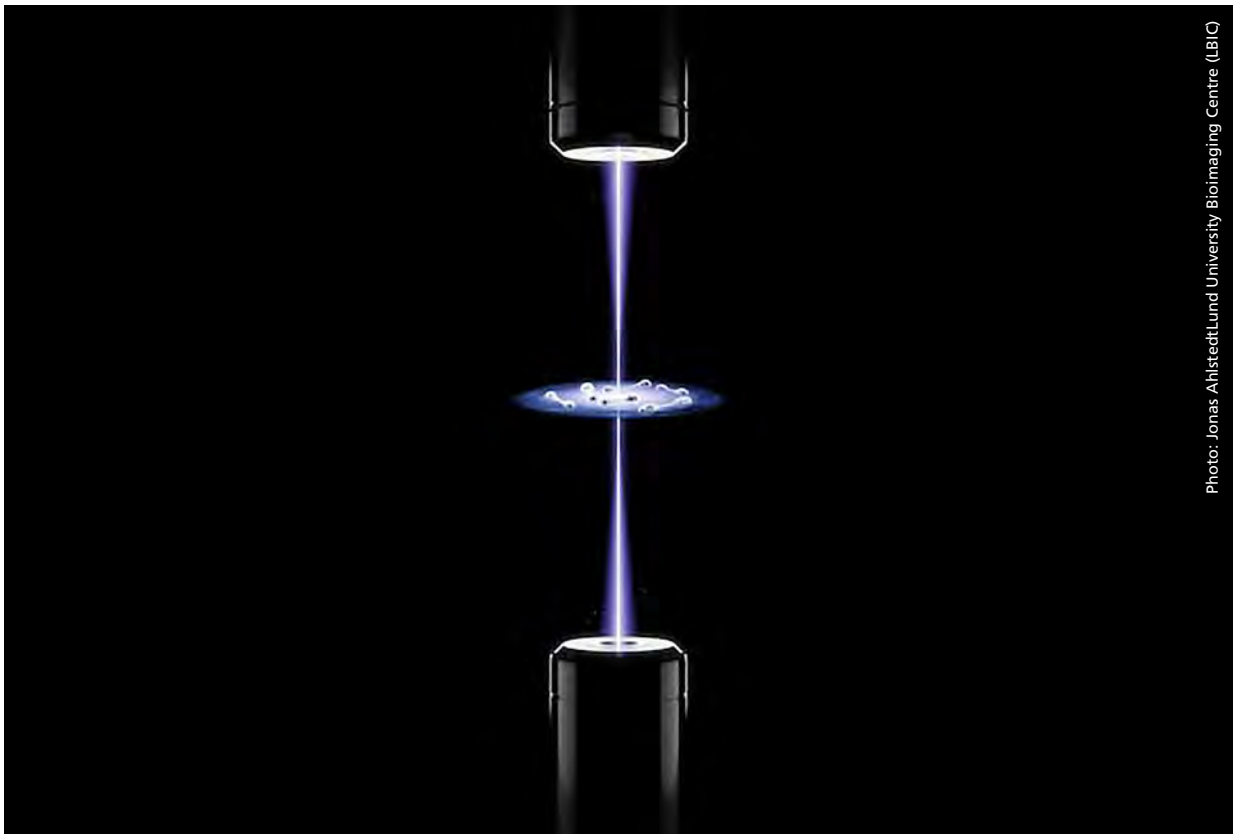
With the plans of moving to Science Village, including the Departments of Physics and Chemistry and parts of Electrical and Information Technology, the vision is to enhance the combined use of complementary characterization techniques. Laboratories from different groups will be located closer together, and multiple informal meeting points for the involved scientists shall be created.

The NanoLund community also uses major cutting-edge characterization tools at synchrotron facilities, such as MAX IV in Lund. NanoLund members are also frequent users of neutron facilities worldwide and collaborate with the ESS (European Spallation Source). Additionally, some members are actively involved in developing new instrumentation at MAX IV and other large-scale research infrastructures.

NCHREM – NATIONAL CENTER FOR HIGH-RESOLUTION MICROSCOPY

The nCHREM facility is situated within Kemicentrum at Lund University. It has state-of-the-art tools for electron microscopy, including a unique Environmental TEM for in-situ experiments. We offer expertise in imaging, element analysis, and sample preparation for a wide variety of sample types. The nCHREM also provides equipment for specimen preparation, image calculation, processing and documentation, including equipment for plunge-freezing of liquids and cryogenic imaging. We have experience in problem-solving, and many industrial partners have used our expertise. The facility has analysed all kinds of materials, from biological samples to high-tech electronic components. The active time on the available instruments is well distributed between many different users within Lund University, external users and teaching. The nCHREM facility is also part of the Lund Nano Characterization Labs.

Scientific publications



Six pairs of atoms in the focus of a laser beam.

SCIENTIFIC PROGRESS

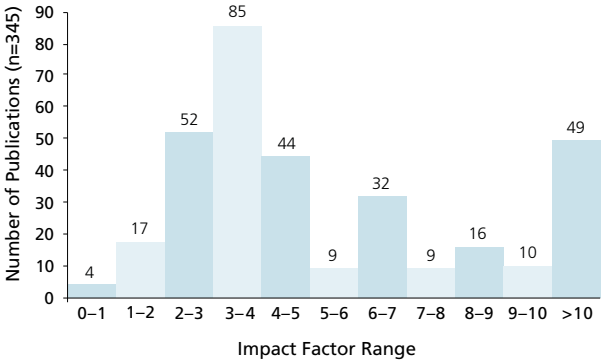
Our most important way of communicating results and providing value to the scientific community is through high-quality scientific publications in widely-cited peer-reviewed journals. In 2020, the number of publications was 394.

The quality of our publications remained high, with an averaged journal impact factor (JIF) of 6.15, averaged over all our publications relevant to nanoscience. 15% of these publications were published in journals with a journal impact factor larger than 10. The overall distribution of the journal impact factor remains similarly shaped compared to the last years. We consider it a good sign that we have a balance between high-impact factor papers with high visibility and publications in archival journals peaking at an intermediate impact factor of around 3 to 4. This balance reflects the mix between excellence and breadth of the research performed at NanoLund.

Publications 2020

394	Publications in total
345	Directly related to nanoscience
49	Nanoscience publications with journal impact factor > 10
23	Nature (incl Nature Materials etc), Science (incl Sc Advances) & PNAS
6.15	Average Journal Impact Factor

Journal impact factor distribution for NanoLund publications in 2020 (327 of the 345 nanoscience publications have a defined JIF)



Education

UNDERGRADUATE EDUCATION

The Engineering Nanoscience Programme at the Faculty of Engineering is a complete five-year degree programme that starts at the university entrance level and leads to a master's degree. This is the only master's degree program in Sweden with nanoscience as a consistent theme throughout all five years. The programme was initiated in 2003 by NanoLund scientists and symbiotically combines education and research with strong industrial connections. It provides a holistic perspective of nanoscience and also of engineering and natural sciences, including biology, biochemistry, medicine, physics, mathematics and chemistry. High-level research activities in the field drive the teaching, and the students have the possibilities to obtain industry experience through projects and internships. As a result, both academia and industry benefit from the highly qualified graduates leaving the programme. In autumn 2020, 45 students started the program; 20 of whom are women, the highest fraction of women since the start of the programme. Like the rest of society, the Nanoscience programme has adapted to the Covid-19 pandemic, with most of the teaching activities being performed on-line. In January 2020, Jonas Johansson started as Programme Director for the Programme.

NanoLund strives for strong interactions with other undergraduate education programmes. At present, more than 90 undergraduate students from several different education programmes are signed up as NanoLund student members. Several events have been organized for the student members, including yearly joint retreats with NanoLund PhD students and postdocs, talks and mingle with NanoLund alumni, scientific talks by young NanoLund scientists and information event about master's projects at NanoLund.

INASCON

The 14th annual INASCON (International Nanoscience Student Conference) 2020 was held in Lund and organized by students from the engineering nanoscience program with the support of NanoLund. The primary purpose of INASCON is to raise interest in nanotechnology by creating a common platform that encourages the exchange of ideas between students from universities around the world and well-known researchers in the field.

The conference took place 11–13 August, and due to the Covid-19 pandemic, it was held on-line. More than 1 000 persons worldwide participated at the conference, making it the largest INASCON conference ever organized.

"Nanoscience is still a rather specific research area, yet applicable in many different fields. With this conference, we aim to inspire students to pursue different carrier paths within nanotechnology", says Linnéa Jönsson, one of the nanoscience students organizing- the conference. NanoLund is proud to have sponsored this event together with Sten K Johnsons Stiftelse, Region Skåne, Lunds kommun and MAX IV.

Engineering Nanoscience statistics 2020

45	students started
44%	of started were women
56%	of started were men
19.38	grade points average needed for high-school students
26	students graduated
42%	of graduated were women
58%	of graduated were men

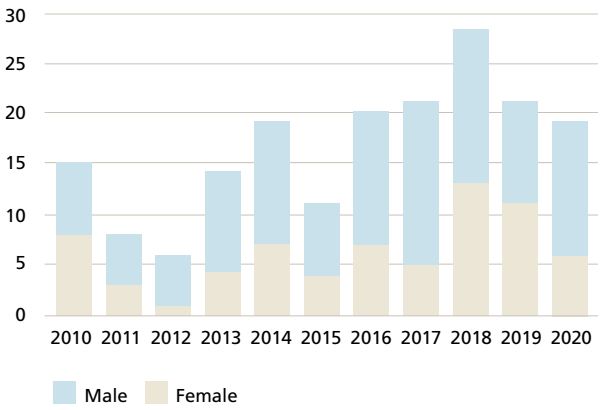
INASCON organizers interviewing Nobel laureate Ben Feringa.

Graduate education at NanoLund

NanoLund is Sweden's largest research environment for interdisciplinary nanoscience and nanotechnology. In 2020, we engaged as many as 145 PhD students in thesis projects ranging from engineering to natural sciences and medicine. This year GenerationNano, a Marie Curie Cofund doctoral programme, started the recruitment of doctoral students to the program. GenerationNano will, in total, offer 14 PhD-students exciting research at the forefront of nanoscience.

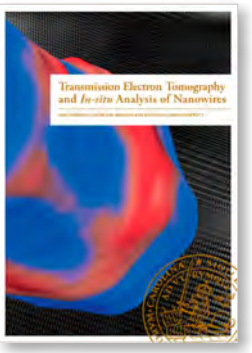
We are very proud of the 19 NanoLund PhDs who graduated in 2020 and wish them all a brilliant career!

NanoLund PhD dissertations 2010–2020

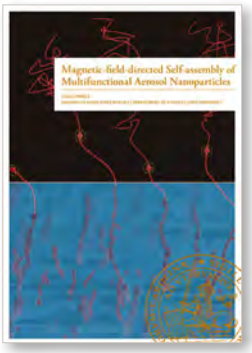


Atena Malakpour Permlid	Functional zoology	From a Road Less Travelled to a Worn Path: Three-Dimensional Tumour Models for Cancer Research and Therapeutics
Axel Persson	Centre for Analysis and Synthesis	Transmission Electron Tomography and In-situ Analysis of Nanowires
Bahareh Goldozian	Mathematical Physics	Interactions and Coherences in Electron Transport trough Serially Coupled Quantum Dots
Calle Preger	Solid State Physics	Magnetic-field-directed Self-assembly of Multifunctional Aerosol Nanoparticles
Florinda Viñas Boström	Solid State Physics	Theory of electronic structure and transport in heterostructure nanowires
Fredrik Lindelöw	Nano Electronics	III-V Nanowires for High-Speed Electronics
Gunnar Eriksson	Mathematical Physics	Solitons, vortices and shell structure in ultracold atomic quantum systems
Johan Agorelius	Neuronano Research Center (NRC)	Development of highly biocompatible neuro-electronic interfaces towards monitoring authentic neuronal signaling in the brain
Karin Lovén	Ergonomics and Aerosol Technology	Exposing the Exposures
Lert Chayanun	Synchrotron Radiation Research	Nanowire devices for X-ray detection
Malin Alsved	Ergonomics and Aerosol Technology	Transmission of Infectious Bioaerosols
Marcus Tornberg	Solid State Physics	Dynamics of a Droplet that Assists III-V Nanowire Growth
Martin Josefsson	Solid State Physics	Quantum-Dot Heat Engines
Mattias Törnquist	Biochemistry and Structural Biology	Secondary Nucleation in Amyloid Formation
Mohammad Karimi	Solid State Physics	Infrared Photodetectors based on Nanowire Arrays with Embedded Quantum Heterostructures
Qi Shi	Chemical Physics	Phase Modulation Two-Photon Microscopy of Hybrid Halide Perovskite
Reza Jafari Jam	Solid State Physics	Advanced patterning and processing for III-V nanowire device fabrication
Vilhelm Malmborg	Ergonomics and Aerosol Technology	Characteristics of Particulate Emissions from Low Temperature Combustion and Renewable Fuels
Xianshao Zou	Chemical Physics	Dynamics of Photogenerated Charge Carriers in III-V Bulk and Nanowire Semiconductors

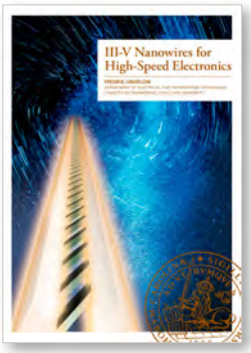

From a Road Less Travelled to a Worn Path

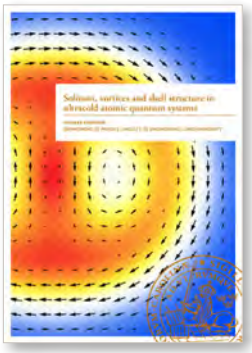

Transmission Electron Tomography and *In-situ* Analysis of Nanowires


Interactions and Coherences in Electron Transport Through Serially Coupled Quantum Dots

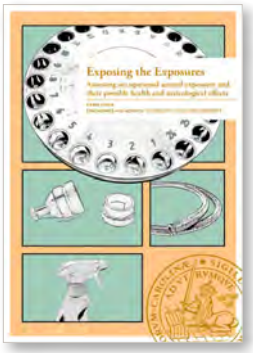

Magnetic-field-directed Self-assembly of Multifunctional Aerosol Nanoparticles

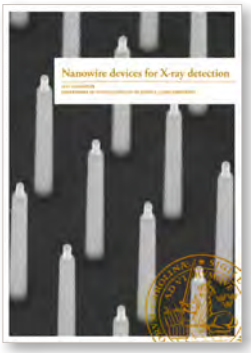

Theory of electronic structure and transport in heterostructure nanowires

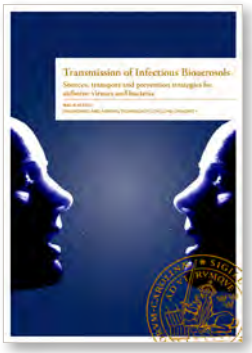

III-V Nanowires for High-Speed Electronics

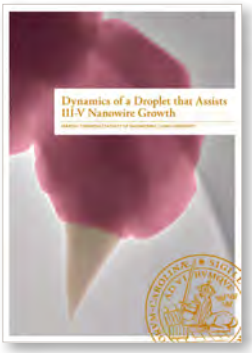

Solitons, vortices and shell structure in ultracold atomic quantum systems


Development of highly biocompatible neuro-electronic interfaces

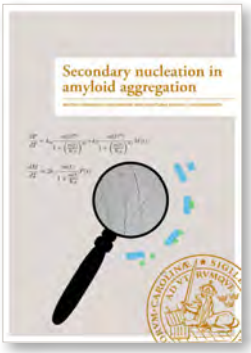

Exposing the Exposures


Nanowire devices for X-ray detection

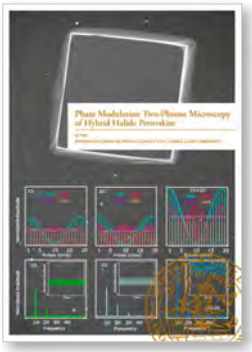

Transmission of Infectious Biosecrosols


Dynamics of a Droplet that Assists III-V Nanowire Growth


Quantum-Dot Heat Engines


Secondary nucleation in amyloid aggregation


Infrared Photodetectors based on Nanowire Arrays with Embedded Quantum Heterostructures


Phase Modulation Two-Photon Microscopy of Hybrid Halide Perovskite


Advanced patterning and processing for III-V nanowire device fabrication


Characteristics of Particulate Emissions from Low Temperature Combustion and Renewable Fuels


Dynamics of Photogenerated Charge Carriers in III-V Bulk and Nanowire Semiconductors

Innovation and collaboration

COLLABORATION WITH INDUSTRY

It is a central, long-term aim for NanoLund to establish a broad and sustainable network of stakeholders in industry, institutes and society. Our vision is to create a forum where companies meet other companies, scientists and stakeholders for new collaborations and perhaps business opportunities. We also hope that they will look for and find their future employees among our undergraduate and PhD students.

The Covid-19 pandemic has prevented us from meeting in person, and instead, we have focussed our efforts to develop collaborations using digital formats and channels. We are particularly happy that close to 2000 people have signed up to follow news, activities and career opportunities regularly posted by NanoLund on LinkedIn.

In dialogue with our stakeholders, three areas have been identified as areas with a demand for collaborations. One such area is to identify and define specific innovation areas where our stakeholders face common challenges and where research within NanoLund can be part of a solution. In order to strengthen the regional innovation ecosystem, we have intensified collaborations with RISE (Research Institutes of Sweden) and Region Skåne. During the year, RISE inaugurated ProNano in Lund. A pilot infrastructure for the production of nanotechnology-based materials that will facilitate the industrialization of nanotechnology in our region

The second area is nanosafety and safe-by-design. Many researchers who are part of NanoLund are also active in the research programme Mistra Environmental Nanosafety. During the year, a number of key activities were organized to highlight nanosafety research from different perspectives. These include a targeted workshop on nanomaterials in waste and risks associated with nanomaterials as they become recycled. During the Lund University Future Week, benefits of nanomaterials were discussed, including potential risks to our environment.

The third area is to develop collaborations and services for the characterization of materials, including gateway activities for MAX IV. The unique capabilities of MAX IV and ESS (European Spallation Source ERIC) enables us to study important scientific questions concerning the properties of different materials. During the year, NanoLund joined forces with another Strategic Research Area, the Sustainable Production Initiative (SPI, at Lund University and the Chalmers University of Technology), in a new collaboration with major Swedish companies from the metals and manufacturing industry. The project aims to facilitate and improve the industry's use of X-rays and neutrons through direct collaborations between industrial and academic researchers. The project will also illustrate how NanoLund and SPI can act as gateway facilities for experiments using X-rays and neutrons.

NEW CONCEPTS – NEW IDEAS

NanoLund aims to identify and develop applications of nanoscience that make a positive impact on society and help address needs and challenges. Researchers within NanoLund are encouraged to validate how research results can be utilized for new concepts and ideas relevant to society and industry. We are very proud of all the companies spun out of NanoLund – as many as 29 companies since the start of the research centre in 1988. On the next page, you will find short descriptions of what

Many NanoLund researchers took part in the research programme Mistra Environmental Nanosafety. Illustrator: Frida Nilsson

they do and their number of employees to indicate the size of their activities.

The Covid-19 pandemic has truly challenged our society in numerous ways, and NanoLund researchers have risen to the challenge.

The aerosol researchers Jakob Löndahl and Malin Alsved have been working on analyzing air samples from patient rooms at Lund University Hospital looking for virus particles. They have also studied the number of particles we emit when we sing to gain a better understanding of the mechanisms for virus spreading through different aerosols that we encounter in our daily life.

The pandemic also calls for new, faster and more accurate tests to detect virus in the human body. Researchers within nanobiology have initiated different projects aiming to apply nanotechnology for the detection of viruses. The goal is to develop cheap tests with efficiencies superior to antigen tests and faster than PCR-tests, which takes several hours from sampling to result. The work has high innovation potential and is performed in collaboration with spin-off companies such as Aligned Bio. Professor Christelle Prinz and her project team were also awarded a prestigious ERC Proof-of-Concept Grant supporting the development.

Table 1. Spin-off companies from NanoLund
Spin-off companies from NanoLund (companies in operation by December 2020, in alphabetical order). The number of employees has been deducted from the latest available public yearly report (2019).

COMPANY		STARTING YEAR	NUMBER OF EMPLOYEES 2019
Acconeer	Develops unique radar solutions based on pulsed coherent radar technology combining extremely low energy consumption with high accuracy.	2011	35
AcouSort	Combines acoustics and microfluidics to separate and sort cells and particles in biological and clinical samples.	2010	7
Aligned Bio (previously AligND Systems)	Utilizes the light-guiding properties of semiconductor nanowires to develop a biosensor platform for analyzing biomarkers such as proteins and other molecules.	2019	No available data
AlixLabs	Provides a method to manufacture nanostructures with a characteristic size below 20 nm for the electronics industry.	2019	No available data
BrainLit	Combines light-emitting diode (LED) technology with knowledge about the effects of light on human anatomy and physiology for new in-door lighting.	2012	10
NordAmps (previously C2Amps)	Develops a new technology for transistors by combining the high performance of semiconductor materials (In(Ga)As-nanowires) with the economy of scale supported by silicon substrates.	2016	1
Cellevate	Provides the biotech industry with cell culture systems where cells are grown in a porous network of nanofibers mimicking different types of body tissues.	2014	4
Glo	Develops LEDs in the colours red, green and blue using III-nitride-based nanowires.	2003	44
Hexagem	Develops wafers of the semiconducting material gallium-nitride using a new patented technology that completely avoids threading dislocations resulting in a material of higher quality.	2015	2
NeuroNano	Develops innovative electrodes for deep brain stimulation (DBS) with the aim to improve the quality of life for people with various neurological illnesses.	2006	4
Obducat	Develops and supplies lithography solutions for production and replication of advanced micro and nanostructures for industrial needs.	1989	42
Spermosens	Develops a diagnostic technology for male infertility aiming to predict the outcome of in-vitro fertilizations.	2019	2
Thyrolytics	Develops a diagnostic tool for measuring thyroid hormones in blood.	2018	2
Watersprint	Develops and manufactures products for water purification using light-emitting diodes (LED) in the ultraviolet spectrum C (wavelengths ranging from 100 to 280 nm).	2013	5
Wren Therapeutics Ltd.	Aims to discover and develop drugs for protein-misfolding diseases such as Alzheimer's and Parkinson's disease. The work is based on research on the chemical kinetics of the misfolding process.	2016	No available data

Outreach

The NanoLund outreach program aims to educate society on nanotechnology, and our ambition is to involve a majority of our members. With the outreach programme, NanoLund wants to spread information about nanoscience and nanotechnology to society at large and schools especially. The outreach activities include safety and sustainability aspects and opportunities to address essential needs in society. The most common action has been popular scientific lecturing; several hundred high school students, the general public and companies in the region have learned about the opportunities offered by nanotechnology.

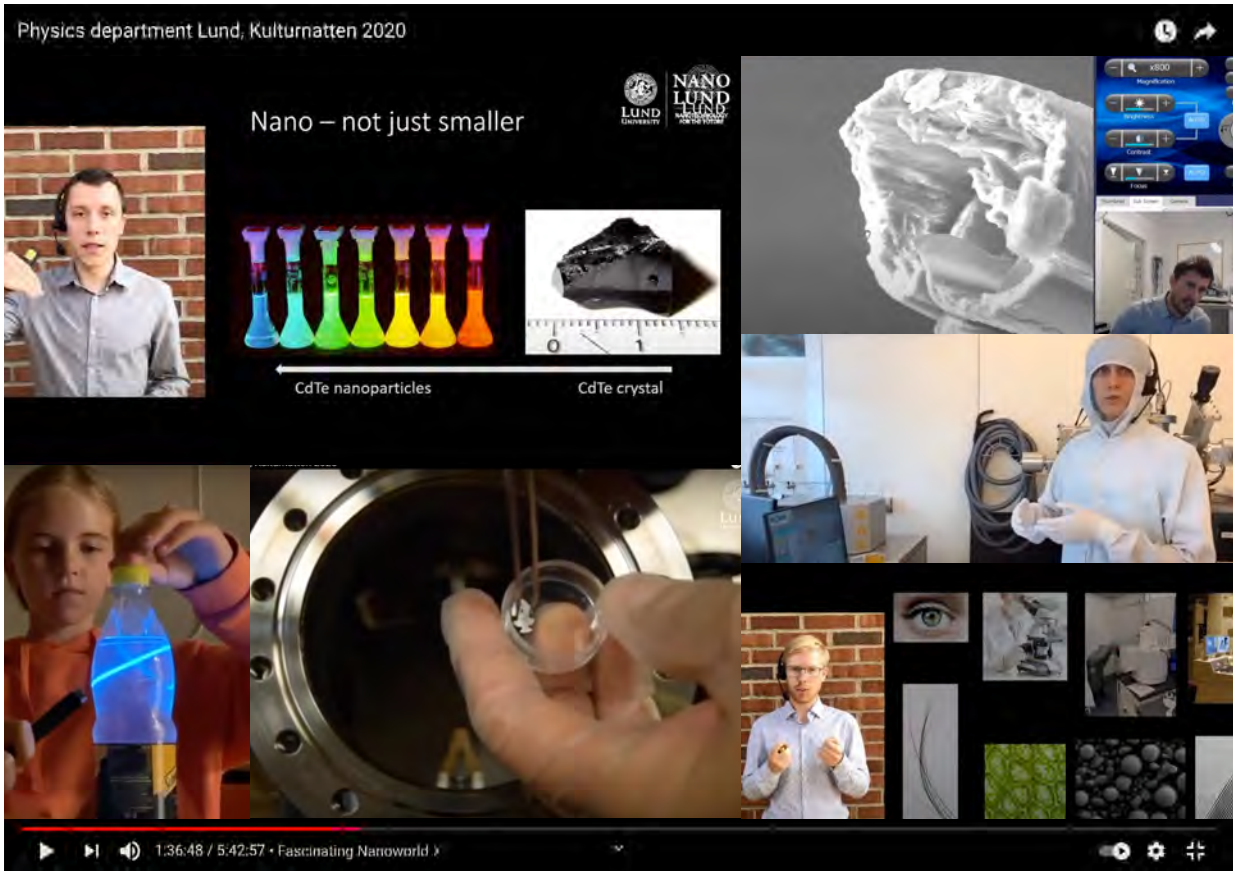
As an example, NanoLund researchers are engaged in the collaborative project 'Framtidskompis' with Malmö Stad and AFRY. In this project, about 175 high school students in Malmö are given further insight into working and business life.

In 2020 Lund's municipality arranged the annual Night of Culture, Kulturnatten, digitally. NanoLund participated with virtual tours of the cleanroom and scanning electron microscope demonstrations. There were also NanoLund competitors in the Physics Science Slam. All the events were live-streamed and had some level of being interactive, with more than 500 viewers throughout the day. The interactive tour of the cleanroom facilities can be visited on the NanoLund web, where presentations and news articles related to nanoscience, nanotechnology and aerosol technology also are made available.

Our members have also been involved in educating high school teachers and participated in science slams. In addition, NanoLund's research results have been widely spread during the year through several press releases, in printed newspapers, and via features on radio and TV.

TWITTER: 18 tweets were seen 26 000 times.

LINKEDIN: Our posts were seen 35 000 times, and of those 3 044 resulted in people clicking on the links we presented.



2020 NanoLund awards

NANOLUND AWARD FOR EXCELLENT TECHNICAL AND ADMINISTRATIVE SUPPORT

The purpose of this award is to emphasize the critical importance of the work done by NanoLund administrative and technical personnel, without which none of our research and teaching would be possible. In 2020 the award was presented to:

Elisabeth Nordström, Finance Officer, Department of Electrical and Information Technology for her devotion to her work and immense sense of responsibility, and for qualified financial support from fixing urgent financial issues to keeping track of financial rules, reporting deadlines and the finance situation, enabling the researchers to focus on their research.

Håkan Lapovski, Facility Manager, Solid State Physics for excellent support relating to the countless small tasks and larger projects needed to keep Lund Nano Lab running smoothly, for his willingness to help out or to find the right person to help out if needed, and for contributing to a great work environment for us all.

NANOLUND EARLY-STAGE RESEARCHER AWARDS FOR OUTSTANDING PERFORMANCE IN TEACHING

The efforts of junior staff like PhD students, postdocs and other young researchers are often crucial for the courses we teach and help form the impression undergraduate students have of our research environment. This award highlights and rewards some of the many great young teachers among our staff and emphasizes the importance of the teaching efforts done by NanoLund researchers. In 2020 it was presented to:

Therese Olsson, PhD student, Solid State Physics. Therese has done an extraordinary job as lab instructor and exercise group leader. Students have reported on her excellent pedagogical skills and dedication to keep explaining until everyone has understood. Course responsible teachers have reported on her ambition to help with improving the courses and their organization.

NANOLUND JUNIOR SCIENTIST IDEAS AWARD

Selection for this award is based on the originality, feasibility, potential impact and initiative of the project as judged across all research areas of NanoLund. Projects for this award are selected among high-quality proposals for novel research projects submitted by master's students, PhD students and postdocs at NanoLund.

In 2020 ten projects were received and evaluated by a group of senior scientists. Five projects were selected for funding (100 000 SEK) for research expenses:

Kim von Allmen, Postdoctoral fellow, Synchrotron Radiation Research – Microfluidic system for sorting single crystals in solution with X-ray diffraction.

Egle Kelpsiene, Doctoral student, Biochemistry and Structural Biology – Gene expression as an indicator of the molecular response in freshwater organism *Daphnia magna* after chronic exposure to polystyrene nanoparticles.

Michael S. Seifner, Postdoctoral fellow, Centre for Analysis and Synthesis – Controlled Crystallisation and Stabilisation of Metastable α-Sn on InSb Nanowires.

Ruben Seoane Souto, Postdoctoral fellow, Solid State Physics – Transport signatures of odd-frequency superconductivity in superconducting nanostructures.

Pavel Kolesnichenko, Postdoctoral fellow, Chemical Physics – Towards Application of Artificial Neural Networks to the Analysis of Two-Dimensional Electronic Spectra of Low-Dimensional Materials.

NANOLUND OPEN AWARD

In 2020 the OPEN award was introduced. This award is presented to a person who, in an outstanding manner is living our core values Openness, Pioneering and Enthusiasm as a true NanoLundian. The OPEN award was in 2020 given to:

Line Lundfald, Centre Coordinator, NanoLund, received the first OPEN award in appreciation of her inspiring work and devotion to the development and support of NanoLund during her time as Centre Coordinator – always systematically optimizing every opportunity possible to make NanoLundians shine with excellence.

Viktor Öwall, Dean at Faculty of Engineering and Chair of the NanoLund Board (2015–2020), given in December 2020, when the assignment as Faculty Dean was terminated. Viktor Öwall received the award in recognition of his exceptional contributions to the strategic development of NanoLund.

Funding

NANOLUND INCOME SOURCES FOR 2020

Funding for NanoLund and our researchers comes from a range of national and international funding agencies. This combination ensures that our interdisciplinary environment has the necessary resources to conduct nanoscience research at the highest international standard.

The total income is assessed as direct funds to NanoLund and our faculty members' income, weighted with their degree of participation in NanoLund.

In 2020 the total income for NanoLund was 216 MSEK. 84 MSEK came from Lund University and 30 MSEK of these were Strategic Research Area funding for NanoLund. 132 MSEK, corresponding to 61% of the total income, was external funding won in competitive calls. See the diagram for funding from individual income sources.

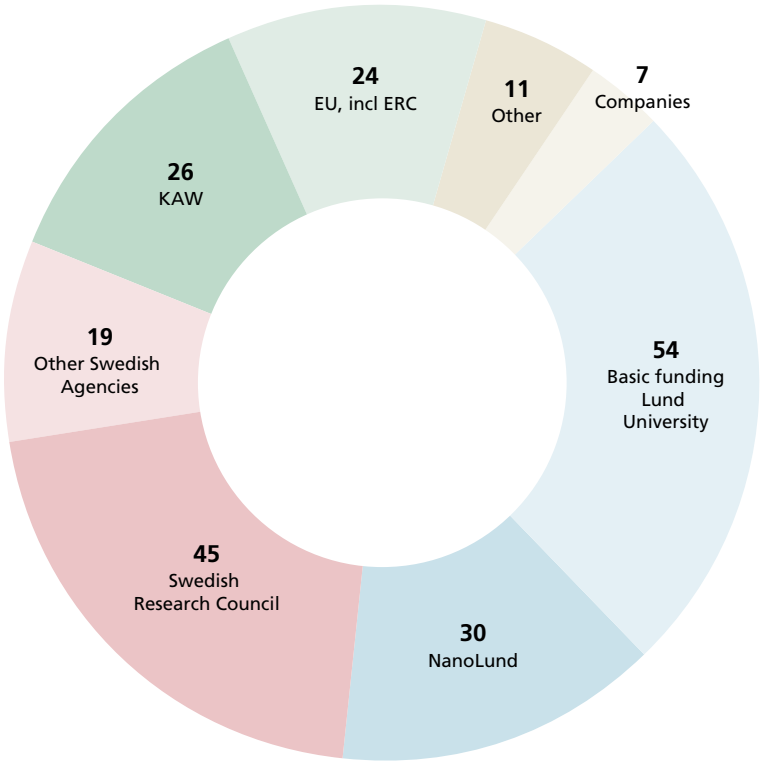
FUNDING HIGHLIGHTS

NanoLundians are active and successful in applying for externally funded grants, and many holds highly prestigious grants.

In 2020 NanoLund grantees included:

- 7 active ERC grants (in total 13 NanoLundians have received ERC grants)
- Participation in 9 EU-projects
- Coordination of 2 of our 9 EU-projects
- 3 Wallenberg Scholars
- 7 KAW projects
- 1 Novo Nordisk Foundation project
- 3 Swedish Research Council Distinguished Professor
- 4 Swedish Research Council Research Environments
- 1 Future Research Leader and 1 Ingvar Carlsson Award from the Swedish Foundation for Strategic Research, SSF

NanoLund Income Sources 2020 (MSEK)



Thanks to our funders

AFA Insurance

Åhléns-stiftelsen

Alzheimerfonden

Candle Innovation

Danish Hydrocarbon Research and Technology Center (DHRTC)

European Commission's Research and Innovation Activities: European Research Council (ERC), Marie Skłodowska-Curie Actions, Horizon 2020 and FP7

FORMAS – Swedish Research Council for Sustainable Development

Forte, the Swedish Research Council for Health, Working Life and Welfare

FQXi (Foundational Questions Institute)

Hjärnfonden – the Swedish Brain Foundation

Independent Research Fund Denmark

LMK Foundation for Interdisciplinary Scientific Research

Lund University

Maja och Erik Lindqvists Forskningsstiftelse

MISTRA, the Swedish Foundation for Strategic Environmental Research

Olle Engkvists stiftelse

Region Skåne

Sanofi

Sweden Water Research

Swedish Work Environment Authority

Swedish-Norwegian Foundation for Equine Research

Sydvatten AB

The Crafoord Foundation

The Danish Council for Strategic Research

The Kamprad Family Foundation for Entrepreneurship, Research & Charity

The Knut and Alice Wallenberg Foundation

The Mats Paulsson Foundation for Research, Innovation and Community Development

The Michael J. Fox Foundation for Parkinson's Research

The Novo Nordisk Foundation

The Office of Naval Research

The Royal Physiographic Society of Lund

The Swedish Energy Agency

The Swedish Foundation for Strategic Research, SSF

The Swedish Heart-Lung Foundation

The Swedish Research Council

Vinnova – Sweden's innovation agency

Volkswagenstiftung

Wenner-Gren Foundations

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This Annual Report 2020 for the NanoLund research environment at Lund University presents scientific, educational, outreach and public impact highlights, progress, data, and trends for and up to 2020. This report is based on material and data compiled and edited by the staff of NanoLund, in particular: **Mirja Carlsson Möller,** Coordination | **Evelina Lindén,** Communication | **Anna-Karin Alm,** External Relations | **Gerda Rentschler,** Project Coordinator | **Anneli Löfgren,** Co-director | **Anders Mikkelsen,** Director | **Maria Messing,** Deputy Director

To order a paper version of the NanoLund Annual Report 2020, please contact **info@nano.lu.se**

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