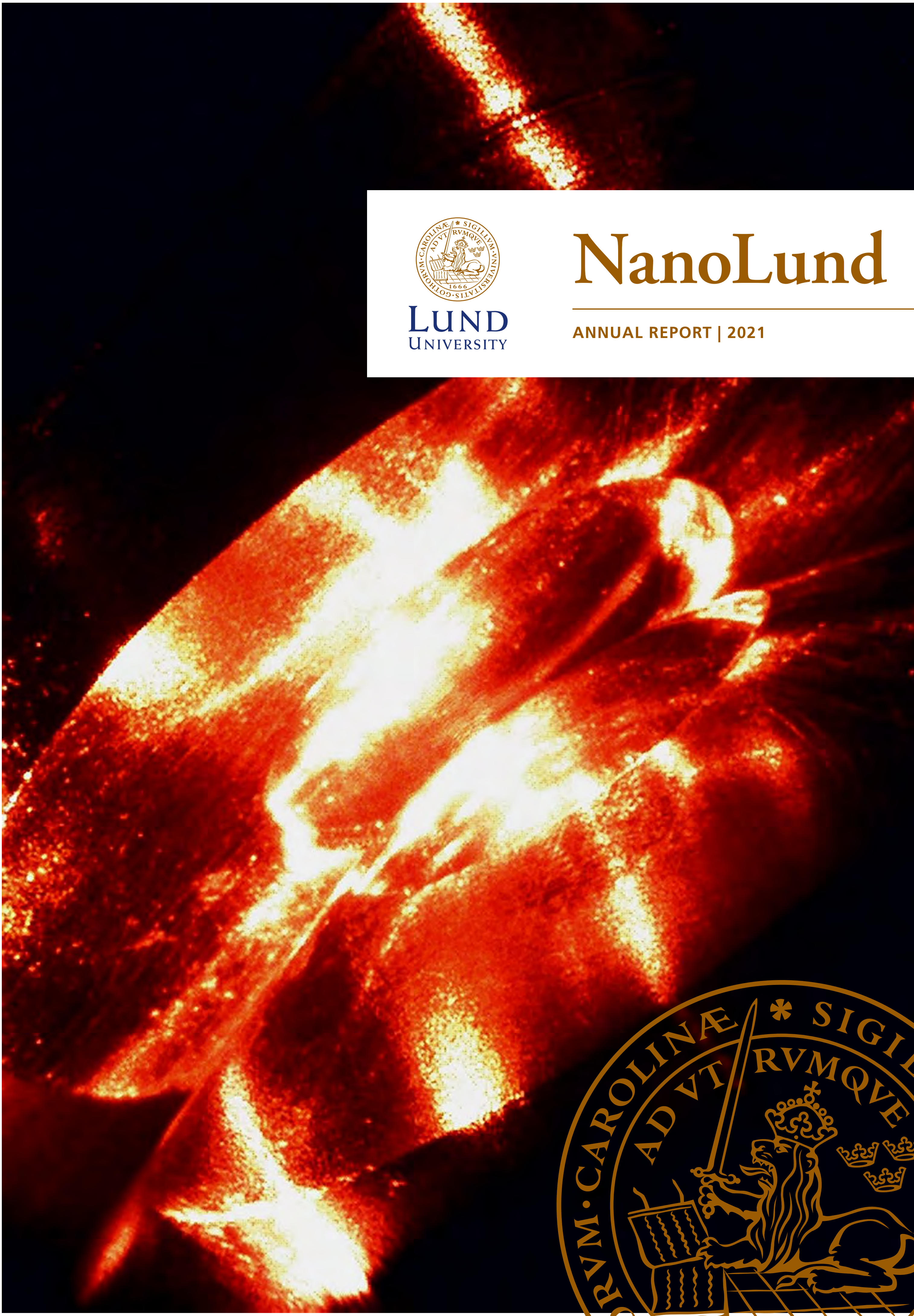

LUND UNIVERSITY

NanoLund

ANNUAL REPORT | 2021

Cover: Photoemission electron microscopy sample under laser illumination, placed in the experimental chamber in front of the microscope's extractor cone. Photo: Lukas Wittenbecher

An artistic rendition of power dependent photoluminescence spectra of a wurtzite-zinc-blended InP heterostructure. Image: Irene Geijselaers

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Working together on nano-science and nanotechnology

Nanoscience and nanotechnology have since the turn of the century developed from buzzwords into a wide-ranging, established discipline with large research groups at all major universities worldwide. It has seen tremendous growth in publications far exceeding that of natural science and engineering in general, and with no slowdown in sight. In this broad and burgeoning field, it is important to identify specific strengths and research topics where we can have an international impact. Here we can look inwards at our own core strengths and opportunities, for example our upcoming expansion of Lund University at Science Village, and how we in collaboration can resolve complex scientific questions. We can look outwards and see where our strengths have the highest impact on society, engaging with companies and institutions around us. We have worked to update our research areas during 2021 and can use this for further exploring our already strong scientific and technological edge. We have great opportunities with new research programs that fit our competencies and ambitions such as the large Wallenberg initiative on Sustainable Materials as well as the European Chips Act.

In 2021, it was a pleasure to meet so many members of NanoLund and learn about all the excellent work performed here. We have a unique openness for sharing and networking that can be used to the maximum now that we can meet in real life again. Meeting representatives from companies and foundations as well as government officials has also been a great experience, giving new collaborations and inspiration for our work. Learning and discussing new research, products, and ideas has every time given a huge boost of energy. I can only encourage all of you to go out and get inspired!

Our students arranged a successful retreat on Ven with about 80 postdocs and PhD students. At our annual meeting, we could finally get together again, this year with an overall theme of Light for Nano – Nano for Light. The opportunity to network in real life was enthusiastically received with 160 attendings, and we further had more than 300 views for the event online. 2021 was a year of slowly getting back to an open world, both locally and internationally hoping for a bright future. However, 2022 has brought a new terrible war to Europe. We help and support those affected as much as we can.

Finally, a warm thanks to all our staff, students, and partners, inside and outside the University, for your ongoing support, understanding and contributions. It is all of us working together that makes NanoLund a great place to do research, educate and make a difference in society.

Photo: Kennet Ruona

Anders Mikkelsen
Director NanoLund

This is NanoLund

NanoLund is the center 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 characterising 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 Laboratory and The European Spallation Source (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

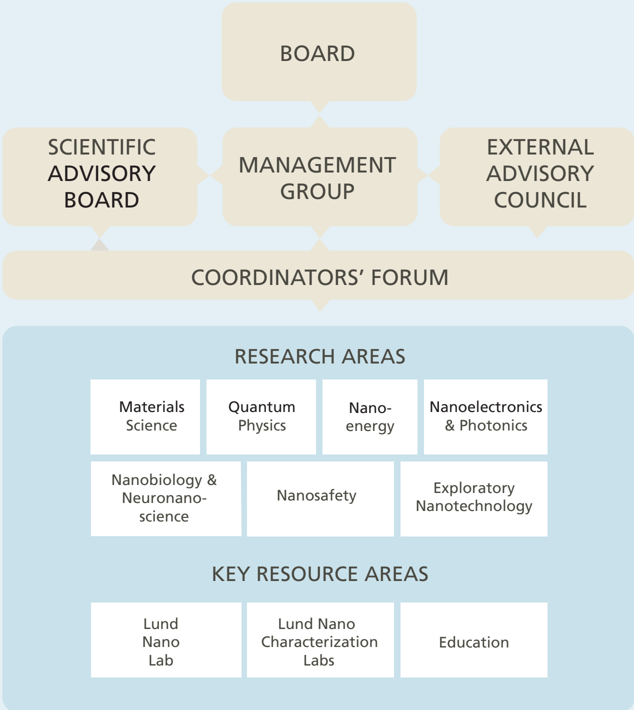
To be a world-leading research centre that uses the unique opportunities offered by nanoscience to advance fundamental science and to address societal challenges.

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.

Organization 2021

NanoLund is headed by a Board, which defines strategy and makes formal decisions. The center is advised by an international Scientific Advisory Board and an External Advisory Council with members from society, academia and industry. Our research is organized into research areas and we have three resource areas that enable and complement the scientific work. Through 2021 we have been working on the structure of our research and resource areas and have decided on a new structure that will be implemented in 2022.



HISTORY

2020	New strategic plan
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

NANOLUND BOARD 2021

Heiner Linke (Chair), *Deputy Dean, Faculty of Engineering, Lund University* | Elizabeth Blackburn, *Faculty of Science, Lund University* | Erik Lind, *Faculty of Engineering, Lund University* | Kerstin Jakobsson, *CEO Kongsberg Beam Technology AS* | Kimberly Dick Thelander, *Faculty of Engineering, Lund University* | Kristian Pietras, *Medical Faculty, Lund University* | Mats Qvarford, *Strategic Partnership Manager, Tetra Pak* | Peter Honeth, *Chair MAX IV Laboratory Board* | Tõnu Pullerits, *Faculty of Science, Lund University* | Jonatan Fast, *student representative, Lund University* | Linnéa Jönsson, *student representative, Lund University*

NANOLUND MANAGEMENT GROUP 2021

Anders Mikkelsen, *Director* | Maria Messing, *Deputy Director* | Anneli Löfgren, *Co-Director* | Christelle Prinz | Ivan Scheblykin | Martin Leijnse | Tommy Nylander

SCIENTIFIC ADVISORY BOARD 2021

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Anna Hall, *Big Science Sweden* | Anna Stenstam, *CR Competence* | Daniel Kronmann, *Region Skåne* | Jan-Eric Sundgren, *Chair of the Swedish Association of Advanced Material (SAAM)* | Lars Börjesson, *Chalmers University* | Madelene Sandström, *the Royal Swedish Academy of Engineering Sciences (IVA)*

NANOLUND SCIENTIFIC ADVISORY BOARD


Robert Feidenhans'l


Stephen Goodnick


Chris Palmstrøm


Heike Riel


Friedrich Simmel


Ulla Vogel


Martin Wolf

2021 in brief

CURRENT NUMBERS

229 MSEK funding

62% from external funding sources

7.15 average impact factor

32 contributing LU divisions

412 number of people engaged in NanoLund

33% of staff are women

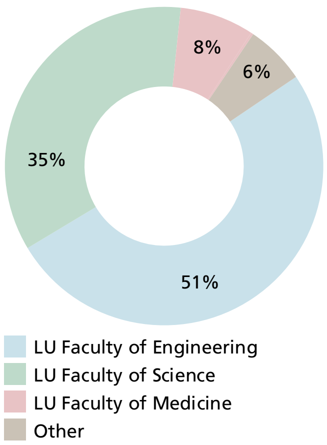
57 Faculty Members

42 Affiliated Faculty Members

157 PhD-students

110 undergraduate student members

FACULTY AFFILIATION



NANOLUND INCLUDES

13 recipients of ERC awards

4 Wallenberg Scholars

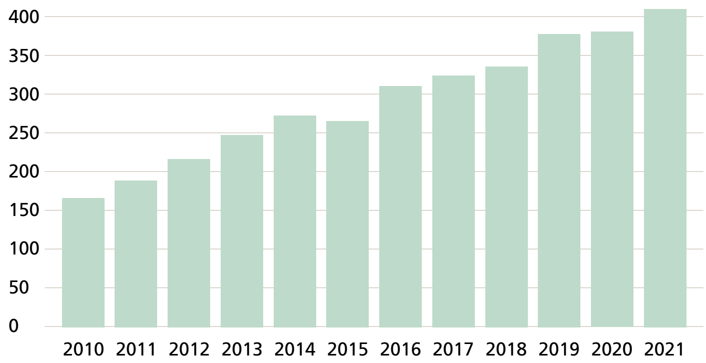
3 holders of VR Distinguished Professor grants

16 ongoing EU-projects

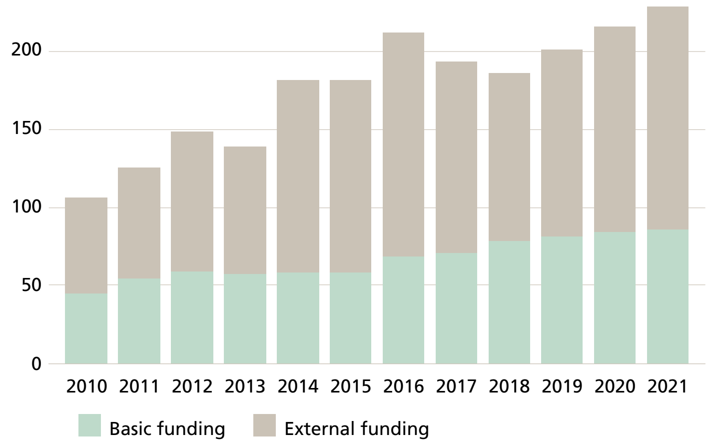
11 ongoing Wallenberg projects and VR Research environment grants

TRENDS

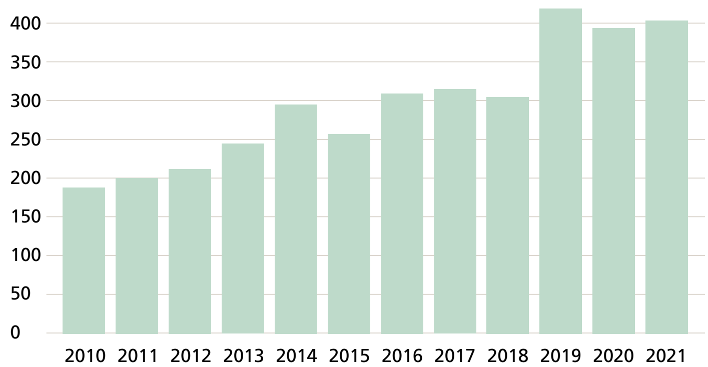
Number of people engaged



Funding over time (MSEK)



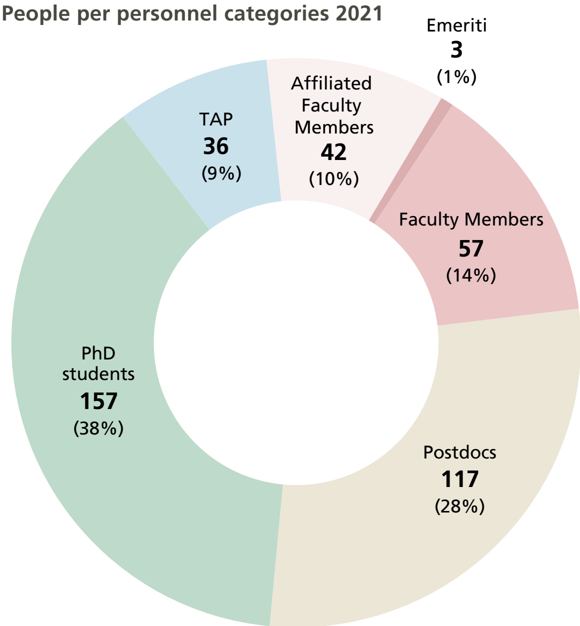
Total number of publications



The people who work with us

In 2021, 412 persons were involved in NanoLund as principal investigator (PI), researcher, PhD student or technical and administrative staff. The majority is distributed over three faculties at Lund University and MAX IV, and about 6% of NanoLund staff is affiliated to institutions other than Lund University. Of the PI:s, the number of Faculty Members and Affiliated Faculty Members were 57 and 42, respectively. 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. Since NanoLund became a strategic research area in 2009, the number of postdocs and PhD students has 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 in 2021 remained 64%, corresponding to 264 full-time equivalents.

People per personnel categories 2021



Gender balance 2021

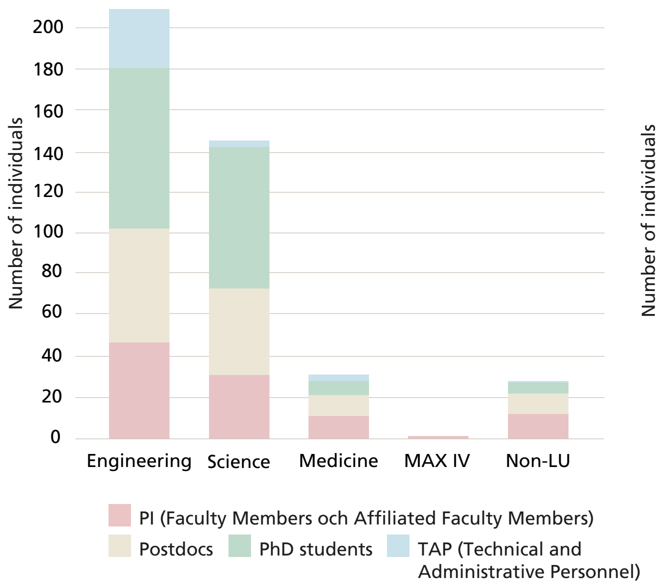
NanoLund strives for gender balance and for being a diverse and inclusive workplace. Overall, 33% of the total staff at NanoLund are women.

The proportion of women at all positions has incresead this year. We will continue taking actions to keep improving the gender balance at all levels over the following years as we work with faculties and departments on even better and more diverse recruitment.

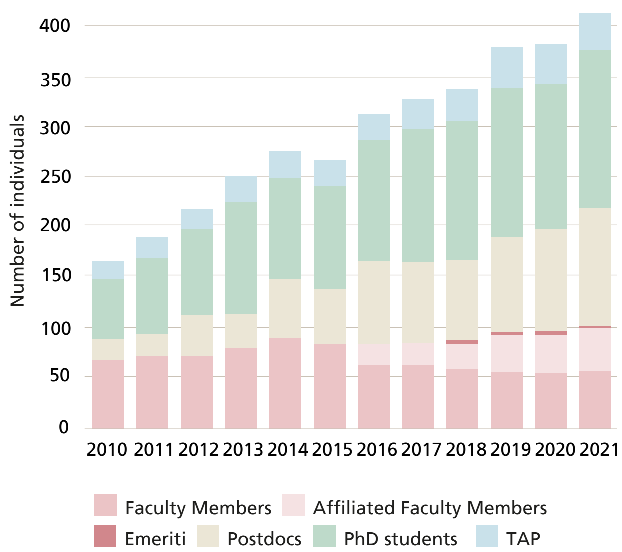
Current statistics for academic positions are:

PI:s	23% women	77% men
Postdocs	24% women	76% men
PhD students	40% women	60% men

NanoLund people by faculty



Personnel trends 2010–2021



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

Our research is organized into several areas that realize NanoLund's vision to be a world-leading research center that uses the unique opportunities offered by nanoscience to advance fundamental science and address societal challenges.

Materials science and manufacturing provide the physical basis for much of our fundamental research as well as technologies for future industrial production. We aim to relate the atomic structure to the properties of a material and understand 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 a challenge is to detect and control these. Our key expertise is in solid-phase nanostructures fabricated from the vapor phase, especially compound semiconductors and metal low dimensional structures. To ensure the 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, often in-situ, techniques to characterize the nanostructures and continuously develop new processes and applications.

Semiconductor technology is vital for future communication systems, energy efficiency within both electronics and electrification, and for improving renewable energy sources and autonomous systems. We strive to find new ways of designing and implementing high-performance electronics on the nanoscale. Smaller device geometries lead to higher operation frequencies, larger small-signal gain, and better packing density. Wide bandgap semiconductors show a strong promise for the power converters that are critical in the electrification of society. Nanoscale field-effect transistors with narrow bandgap materials can realize and explore the high-frequency performance towards THz. Optoelectronic devices are developed for high-performance solar cells, light-emitting diodes and photodetectors. Device design is explored in the atomistic limits to push performance to extreme levels, and we work towards functional integration on Si and Si CMOS.

Quantum physics is where we develop the theoretical tools to better describe quantum phenomena, work to experimentally observe them, and then identify advanced device concepts where quantum effects enable better performance. In nanostructured systems, pronounced quantum behavior gives rise to exciting new fundamental physics as well as potential applications.

The superposition of states and entanglement open completely new perspectives for sensing and communication technology. We explore novel quantum states in many- and few-body systems, photons interacting with quantum systems, and superconductor-semiconductor hybrid structures. Quantum thermodynamics develops 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.

Photons concerns light-matter interactions in nanoscale materials and includes experimental and theoretical research where electromagnetic radiation from microwaves to X-rays is used as a probe, generated or absorbed by the material. We employ a broad range of methods, from basic spectroscopic techniques to combinations of time- and spatially-resolved probes, and different phenomena are harnessed, such as absorption, photoluminescence, electroluminescence and scattering. We study light-triggered exciton and charge carrier dynamics in a variety of nanostructures, use X-rays for locally probing the structural or electronic properties of semiconductors and catalytic centers, investigate photophysical properties of individual nanostructures, and model interactions between light and nanostructured semiconductors, as well as interactions in complex materials.

Life-science and nanoscience utilize our capabilities to create structures on the relevant length scales for cells and molecules for fundamental studies in novel areas and for biomedical applications in areas where there are urgent needs for better functioning tools within research and health care. We strive for a detailed understanding of the interactions between cells and nanostructures concerning cell behavior, physiology and mechanics. This knowledge will allow us to develop novel nanoscale tools with applications in biology and medicine. For example, nanoscale devices that can interact with cells with minimal perturbation or single-molecule sensitivity; injection, nanobiopsy, mechanosensing, or nanostructured tools that can control the cell behavior with respect to differentiation, migration, proliferation and stimulation. We work for translation of results into applications in biophysics, brain science, diagnostics and personalized therapy.

Nanosafety explores the fundamental connections between nanostructure properties and human and environmental toxicology, as well as emissions and exposure in all stages of the lifecycle of a nanomaterial, helping to provide the tools needed for 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.

Inside stages of a dry dilution refrigerator (Oxford Instruments Triton 200). Photo: Adam Burke

Looking back at highlights of 2021

WHY WE NEED SCALING UP: NANOLAB SCIENCE VILLAGE

The need for high technology for precision medicine and sustainable, renewable energy is growing. To achieve a healthier and more sustainable society, we need to strengthen research resources and infrastructure. As part of Lund University's contribution to "Almedalsveckan", an annual democratic place for dialogue, exchange, and unexpected meetings, we gathered a panel to discuss how nanotechnology can contribute to a sustainable future, the importance of research infrastructure, and the opportunities offered by the environment around Science Village and the new Nanolab Science Village.

NanoLund's deputy director Maria Messing and Johan Wester introduced the event with a short movie, followed by a talk with Kerstin Jakobsson, former CEO of Medicon Village, Anders Mikkelsen, director of NanoLund, Camilla Modéer, member and senior adviser, Royal Academy of Engineering Sciences (IVA) and Viktor Öwall, pro-vice-chancellor for infrastructure and digitalization, Lund University.

https://almedalsveckanplay.info/61785

HOT-CARRIER OPTOELECTRONIC DEVICES BASED ON SEMICONDUCTOR NANOWIRES

Semiconductor nanowires may realize an alternative approach of photovoltaics – conversion of sunlight to electricity – so called hot carrier photovoltaics, that in theory could be more efficient than possible in conventional solar cells of today, where a lot of the energy is lost in the form of heat.

Early studies suggest nanowires have properties that can help realize hot-carrier photovoltaics, such as reduced thermal conductivity, increased lifetime, and an ability for precise tailoring of materials at the nanometer scale, however more studies are needed to fully evaluate the potential of this technique and we outline what knowledge is still missing.

J. Fast et al

Applied Physics Reviews 8, 021309 (2021)

https://doi.org/10.1063/5.0038263

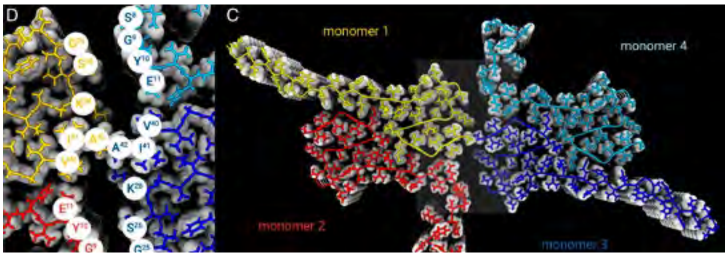
Vanya Darakchieva, professor of Solid State Physics, was one of the keynote speakers at NanoLund annual meeting October 2021.
Photo: Evelina Lindén

"Light for Nano" – a long-awaited annual meeting

Finally, the NanoLund community could arrange for an annual meeting together at the same venue. The theme of the meeting was "Light for Nano – Nano for Light". Program chairs Ivan Scheblykin and Jesper Wallentin had put together an exciting program. The program included invited and contributed talks on the topics:

- Radiation from microwaves to visible light and X-rays to study the nanoworld
- Generation and detection of radiation by nanodevices
- Systems from semiconductors to nanoparticles and nanowires and biologically related objects

The annual meeting had 160 participants present and some 100 online. 27 speakers including Anders Mikkelsen's introduction, poster pitches, 47 posters, and presentations of Seedling Projects – also known as the Junior Scientist Ideas Awards.



To the right: A cross-section of a beta amyloid fibril made by tetramer units forming β-sheets stacked along the fibril axis, and (left) zoom of Aβ42 fibril core showing the amino acid residues of contact between two filaments. Picture by V. Lattanzi et al, PNAS.

NEW DETAILED KNOWLEDGE OF HARMFUL PROTEIN CAN HELP FIGHTING ALZHEIMER'S DISEASE

Using X-ray and neutron scattering, a team of researchers in Lund has succeeded in mapping the fibril structure of the beta-amyloid 42 protein that contributes to Alzheimer's disease.

"A deeper understanding of amyloid beta 42 fibril structure could guide the development of drugs that inhibit the formation and spreading of harmful oligomers", says Veronica Lattanzi, a biochemistry doctoral student at NanoLund, Lund University.

To study amyloid beta 42 in detail, the research team carried out advanced X-ray and neutron scattering experiments. Thanks to the scattering pattern created in the lab, the researchers were able to identify a number of previously unknown features of the fibril.

"In addition, by combining small angle scattering studies with solid-state NMR established we were able to localize the amino acids residues on the fibril surface itself", says Veronica Lattanzi.

V. Lattanzi et al
PNAS Nov 2021, 118 (48)
https://doi.org/10.1073/pnas.2112783118

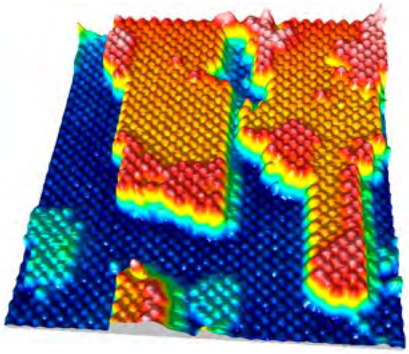
NANOLUND STUDENT RETREAT MOST ATTENDED EVER

After having been postponed last year due to the pandemic, the annual NanoLund retreat for student members, PhD students and postdocs did a well-received return in October.

With roughly 80 attendants from 15 different divisions, it was probably the most attended and diverse retreat so far.

The participants spent a large part of the retreat in smaller groups where they shared their research background and interests with each other and discussed how their various expertise could be combined to benefit from each other. The retreat included some seminars and especially welcome was an interactive workshop by VentureLab, where the participants got to practice how to pitch their ideas efficiently.

With a focus on networking, attendants from across NanoLund disciplines enjoyed two days filled with activities at Backafallsbyn on the island of Ven. Photo: Oskar Ström



Arsenic and bismuth atoms on surface terraces of a GaAs nanowire. The red structures are GaBi islands. Figure: Johan Knutsson / Lund University / Nature Communications

NOVEL NANOSTRUCTURE FORMATION WITH ATOMIC-SCALE PRECISION

Site-selected crystal material synthesis at the atomic scale has been a long-standing challenge. NanoLundians Rainer Timm and Yi Liu use nanowire crystal phase heterostructures as templates for self-selective growth of one- and two-dimensional GaBi nanostructures, which allows a versatile design with atomic-scale precision.

"This opens the path towards monolayer thin nanostructures with variable width atomically sharp borders, and promise for exotic electronic phases of matter", says Yi Liu, PhD student at Synchrotron Radiation Research and NanoLund.

Y. Liu et al
Nature Communications 12, 5990 (2021)
https://doi.org/10.1038/s41467-021-26148-4

SUSTAINABILITY IN FOCUS FOR NEW PHD STUDENTS

In 2020, NanoLund was awarded GenerationNano, a Marie Skłodowska-Curie COFUND nanoscience doctoral training program to address sustainability challenges in materials science, biomedicine and energy, funded by Horizon 2020.

14 PhD students were recruited internationally during the pandemic and made their way to Lund. Now, with restrictions eased, it was finally possible to have a kick-off meeting, interact and identify synergies between their projects. The students were also encouraged to fully make use of the benefits for NanoLund members, specifically networking, collaborations, funding and IP support.

The freshwater zooplankter Daphnia magna is an important keystone species in freshwater habitats around the world, and a common model organism for conducting toxicological assays on various substances. Photo: Per Harald Olsen/NTNU

DOUBLE INNOVATION PRIZE TO NANOLUND

NanoLund researchers Martin Hjort, Yang Chen, and Magnus Borgström have been awarded the Lund University and Sparbanken Skåne's prize for future innovations. Their projects are named "Overcoming the shortage of blood stem cell donations with the help of nanotechnology" and "Transparent solar cells: solar cell windows".

Martin Hjort has together with Ludwig Schmiderer and Jonas Larsson addressed the problem of lack of blood stem cell donations in an interdisciplinary way. By combining leading nanotechnology with stem cell biology, they have developed a method that can give more people access to a blood stem cell donation – which is the difference between life and death for many patients with blood diseases. They won the grand prize in the employee category.

Researcher Yang Chen and professor Magnus Borgström got an honorary award for their project "Transparent solar cells: solar cell windows". Since the need for sustainable energy solutions is enormous, we could solve our big problem of finding alternatives to oil, coal, and gas if we could capture the sun's rays in a smarter way.

Yang Chen wants to create transparent solar cells that can be used on windows. By attaching semiconductors of nanowires to a transparent foil, it becomes possible to use solar cells not only on roofs but also on windows. It is even possible to produce solar cells in different colors, such as changing curtains.

NATURALLY OCCURRING BIOMOLECULES HAVE THE POSSIBILITY TO BUFFER AGAINST POTENTIAL TOXIC EFFECTS

As the use of engineered nanomaterials increases, so does the risk of them spreading to natural ecosystems. This study investigates how a surface corona formed by naturally occurring organic material affects the toxicity of metal nanoparticles.

"Once the particles had been in contact with the naturally organic molecules, we observed a reduction in the toxicity induced by the nanoparticles", says Mikael Ekvall, a Principal Investigator at NanoLund.

The study "Adsorption of bio-organic eco-corona molecules reduces the toxic response to metallic nanoparticles in Daphnia magna" shows that the toxic effect of nanoparticles of tungsten carbide cobalt and cobalt on the crustacean Daphnia magna is postponed in the presence of natural biological degradation products (eco-corona biomolecules).

"The results highlight a method that allows for more environmentally realistic toxicity testing. Most often, toxicity tests are performed in clean water that don't reflect the environment which the particles will be in once released out into nature."

M. T. Ekvall et al
Scientific Reports 11, 10784 (2021)
http://dx.doi.org/10.1038/s41598-021-90053-5

NEW PROFESSOR IN MATERIAL SCIENCE

Vanya Darakchieva has been recruited as professor in Material Science at Lund University and joined NanoLund in 2021. Vanya Darakchieva brings world-class expertise in wide bandgap semiconductors, in particular for high frequency and power applications. She is also pioneering novel characterization methods and spectroscopy techniques, most recently terahertz ellipsometry. We are all very happy to welcome her in the NanoLund community!

Matilda Forni with the ultra-thin microelectrodes during production.
Photografer: Agata Garpenlind

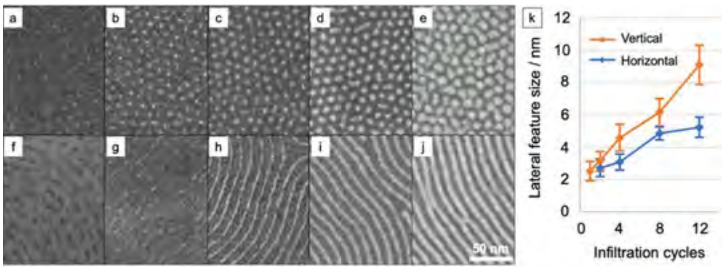
PAIN RELIEF WITHOUT SIDE EFFECTS

A research team led by professor of neurophysiology Jens Schouenborg developed a method to combat pain via personalised stimulation using ultra-thin, tissue-friendly microelectrodes.

"The electrodes are very soft and extremely gentle on the brain. They are used to specifically activate the brain's pain control centres without simultaneously activating the nerve cell circuits that produce side effects", explains Jens Schouenborg.

"We have achieved an almost total blockade of pain without affecting any other sensory system or motor skill, which is a major breakthrough in pain research. Our results show that it is actually possible to develop powerful and side effect-free pain relief, something that has been a major challenge up to now", explains Matilde Forni, doctoral student and first author of the new pain study.

M. Forni et al
Science Advances 7, 41 (2021)
https://doi.org/10.1126/sciadv.abj2847



Scanning electron microscope images showing an increase in lateral alumina feature size as a function of number of cycles.
Picture: A. Löfstrand et al, ACS Applied Nano Materials

TRANSISTOR FABRICATION WITH LOW-COST PATTERNING TECHNIQUE

The study investigates the possibility of selectively infiltrating alumina into the sugar-component of a block copolymer in a thin film, self-assembled into patterns with a periodicity as small as 12 nm. The remaining hybrid pattern is actually shown to be suitable as an etch mask when transferring the pattern into silicon. The result is a pattern consisting of new alumina-containing hybrid material, which allows the non-infiltrated polymer part to easily be removed. This low-cost patterning technique, easily scalable for large areas, can transfer 12 nm pitch features into silicon, which could be of use e.g., in future generation of fin field-effect transistor (FinFET) patterning.

A. Löfstrand et al
ACS Applied Nano Materials 2021, 4 (5), 5141–5151
https://doi.org/10.1021/acsanm.1c00582

BILLIONS TO MATERIALS SCIENCE FOR A SUSTAINABLE WORLD

The Knut and Alice Wallenberg Foundation is investing over SEK 3 billion in research that creates the conditions for a sustainable society. This will be done by developing new and improved materials and manufacturing processes, which, among other things, aim at better technology for the energy systems of the future and the control of pollution and toxic emissions. In addition, an increased investment in renewable materials of forest products is included. For Lund University, this means around SEK 500 million in the coming years.

Anders Mikkelsen, professor of synchrotron light physics and director of NanoLund, believes that the investment also means a lot for our collaboration with MAX IV.

> **"We get a giant boost! The funding will make it easier to attract younger, excellent researchers who fit in well with the faculty's ambition for renewal and strengthening."**

2021 marked the year for semiconductor chips becoming a hot topic – due to a global shortage, with an impact on the entire electronic industry spanning from engines to toys. At NanoLund, research and development of semiconductors has been part of our work for decades and this mission is more relevant than ever to sustainability as well as the digital economy.

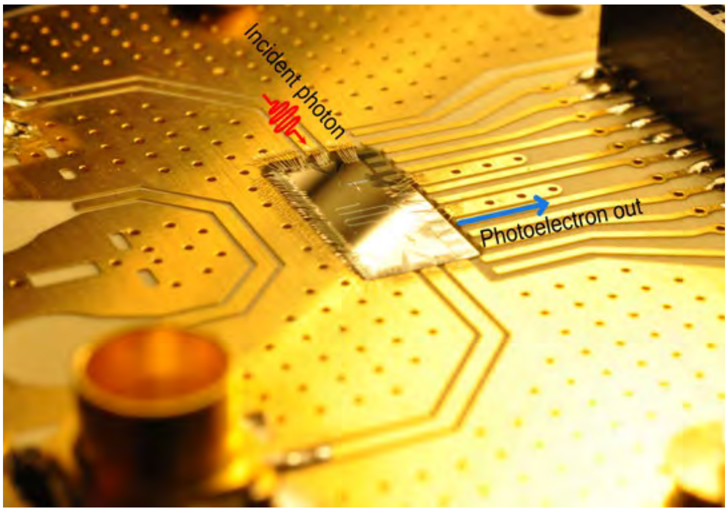
SMARTER AND MORE EFFICIENT ELECTRONICS

A cornerstone of our modern society is digital electronics. Artificial intelligence and internet of things require circuits where huge amounts of data are handled with minimal energy consumption. Mattias Borg and his research group at NanoLund, Lund University, build neuromorphic electronics inspired by the biological brain, of artificial neurons and synapse devices based on novel ferroelectric oxide thin-film materials. Detailed understanding of the materials obtained by characterization at MAX IV, as well as design and modelling of system level performance with Ericsson – builds the foundation for a future Lund Neuromorphic Computing Platform. This research is currently funded by the Swedish Research Council and a Strategic Mobility Grant from SSF.

HOSTING SEMICONDUCTOR SEMINAR AT THE EU DAY LUND

At the EU Day Lund – a new venture and annual forum for strategic discussions on common future challenges and societal shifts, gathering decision-makers and researchers from the public, private and research sectors, NanoLund hosted a seminar on the global shortage of semiconductors. Providing a secure and stable digital infrastructure is central to the function of our society, and critical for the transition towards a climate-neutral economy. Europe is now mobilizing to become self-sustaining and world-leading.

Discussants were Anders Mikkelsen, Lars-Erik Wernersson, Dr Colette Maloney, Head of Unit "Microelectronics and Photonics Industry" European Commission – DG Communications Networks, Content and Technology, and Igor Tasevski, Vice President and Head of Product Development Unit Radio, Ericsson.



Close-up of the new detector. The nanowire used is so small that it is not even visible in a light microscope. Photo: Waqar Khan.

TWO IMPORTANT BREAKTHROUGHS IN QUANTUM TECHNOLOGY

Superconductors are a cornerstone of quantum computers and particle detectors, among other things. However, a common problem is that their efficiency is degraded by various interferences. Now, researchers have come one step closer to explaining what is happening through high-precision measurements.

"It is difficult to measure what happens inside a superconductor, but a new technique simplifies things by opening a 'tap' and letting the unbound electrons jump out to a copper conductor, allowing us to count the unbound electrons with a charge detector", says Peter Samuelsson, professor and principal investigator at NanoLund.

In another study researchers created a microwave detector using semiconducting nanowires. A major advantage of these nanowires is their ability to connect to existing technology. Their properties also form the basis for the major breakthrough that could result in better quantum computers.

"It is thanks to the nanowires that we succeeded in detecting photons continuously, by converting them into a measurable flow of electrons. This means that the detector does not need to know when the photon arrives, which is often required in the microwave detectors that are currently available", says Ville Maisi, principal investigator at NanoLund.

E. T. Mannila et al
Nature Physics 18, 145-148 (2022)
https://doi.org/10.1038/s41567-021-01433-7
W. Khan et al
Nature Communications 12, 5130 (2021)
https://doi.org/10.1038/s41467-021-25446-1

MINISTER OF EU AFFAIRS PAID NANOLUND A VISIT

"We've been given a very fascinating description of how far ahead we are in Sweden and here in Lund, when it comes to research and development of the most valuable technologies we currently have: those of nano-scale components in semiconductors and other aspects of modern technology. If there is anything that can lead us forward – it is this research, there's no doubt about that", Swedish Minister of EU Affairs Hans Dahlgren concludes after visiting NanoLund.

He and his entourage took a good look at the Lund Nano Lab alongside Jonas Hafström, chair of University Board, and Lena Eskilsson, deputy vice-chancellor Lund University, NanoLund's director Anders Mikkelsen, co-director Anneli Löfgren, head of Lund Nano Lab Luke Hankin, and professor of Nanoelectronics Lars-Erik Wernersson.

"I'm so happy that the research here in Lund receives quite an amount of EU money, because that's proof of what we think is important – to invest European money in joint solutions not least in terms of research – is a very good start", says Hans Dahlgren.

PAVING THE WAY FOR SMALLER AND FASTER COMPUTINGS

The metal oxide field effect transistor (MOSFET) is the building block of electronic systems, and the transistor scaling has been a main driving force in semiconductor industry for smaller and faster computing. As the device dimension reaches nanometer regime, the performance has become limited by the parasitic elements such as resistances and capacitances.

This capacitance scaling study helps to understand the various intrinsic and parasitic capacitances of a MOSFET. Results show that spacer profile and device layout play significant role in minimizing parasitic capacitances.

N. S. Garigapati et al
IEEE Transactions on Electron Devices 68, 8 (2021)
http://dx.doi.org/10.1109/TED.2021.3092299

While in Skåne, Swedish Minister of EU Affairs Hans Dahlgren and his entourage particularly asked for visiting NanoLund – and had a close look at the Lund Nano Lab. Photo: Evelina Lindén

Cutting-edge infrastructure – open research facilities, world-class clean rooms and state-of-the-art equipment

The scientific work done at NanoLund is enabled and complemented by our infrastructures: Lund Nano Lab – the nanofabrication facility; and Lund Nano Characterization Labs – a distributed network of many characterization laboratories at Lund University.

LUND NANO CHARACTERIZATION LABS

NanoLund includes an extensive range of cutting-edge characterization instruments and techniques, ranging from microscopes capable of single-atom imaging to ultrafast spectroscopy laboratories that are 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, biomechanics, as well as many-body and transport theory. Cornerstones of our success are the development of cutting-edge characterization methods and the enthusiastic sharing of expertise and knowledge. To strengthen and coordinate these efforts, Lund Nano Characterization Labs was created in 2009.

With the new possibilities opened up by the planned move to Science Village, the vision is to enhance the combined use of complementary characterization techniques. Plans are ongoing for how to locate laboratories from different groups 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, and free electron lasers. 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 at Kemicentrum at Lunds University. Here state-of-the art atomic-level imaging, element analysis, and sample preparation for hard materials, biological materials and even liquids is performed. nCHREM provides electron microscopes for analytical high resolution work, surface imaging (SEM), Cryo-TEM for sensitive samples and a unique Environmental TEM where chemical reactions and crystal growth can be performed at high temperatures, while recording videos with atomic resolution, simultaneously with element analysis. A plunge-freezing facility for liquids is provided for preparing specimens for imaging at cryogenic temperatures. 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 a member of Lund Nano Characterization Labs.

LUND NANO LAB – MYFAB LUND

Lund Nano Lab (LNL) is a key resource for nanoscience and nanotechnology at NanoLund. The cleanroom facility serves the micro- and nanofabrication needs of multiple research groups in strategically important fields at NanoLund. The infrastructure is continuously updated and is supported by a dedicated team of highly educated lab personnel.

LNL constitutes one node of the national infrastructure, Myfab, offering open access facilities for academic and industrial researchers, alike. Tight collaboration with other Myfab nodes, grants users access to specialist equipment, expertise and capabilities that may not be available locally. Myfab has important collaborations with the Nordic Nanolab Network (NNN).

In 2021, there were 114 active academic users from 32 different research groups representing multiple faculties at Lund University, 3 institute users and 19 commercial users from 8 companies. There were 41 new users receiving introductory training to LNL. In the period 2020–2021, the number of booked hours from academic users was 17 % less than pre- pandemic years, without the dedication of the staff to train users and keep the lab open through this period, the performance

LNL IN 2021

276	Users with access
136	Active users
41	New users
32	Research groups
114	Research group users
8	Companies
19	Company users
3	Institute users
49 901	Booked hours

would have been worse. As well as providing training for new users, the expert staff have been consulted in the initial stages of several projects with instrument scientists at both MAX IV and ESS.

In a defining moment for the future of LNL, the board of LTH authorized the procurement of a 1400 m2 Nanolab at Science Village (NLSV), which together with ESS and MAX IV, will be a third major infrastructure at Brunnshög. In advance of the move to Brunnshög, concerted effort continues to secure equipment funding. In 2021, the LNL team installed a Heidelberg Mask Less Aligner and completed the procurement of an Atomic Layer Deposition (ALD) tool. Procurements for a resist processing system, a pulsed laser deposition (PLD) tool and a metal organic physical vapour epitaxy (MOVPE) tool are underway.

Innovation and collaboration – how we engage in societal needs

COLLABORATION WITH INDUSTRY

Our vision is to apply cutting edge nanotechnology to address societal needs and collaboration and innovation are central activities to reach that goal. By engaging in industrial and societal needs, we can contribute with new solutions. This means that we aim for collaborations within innovation and development areas where our stakeholders face common challenges and where research within NanoLund can be part of a solution.

We are constantly working to develop long-term collaborations with stakeholders in industry, institutes, and society. During the year the Faculty of Engineering has prepared for a strategic collaboration agreement with Volvo Cars. The car industry is transforming and nanotechnology is key for innovation within semi conductors, power electronics, sensors, new materials and safety. NanoLund has contributed to the dialogue and starting from 2022 we will have an industrial PhD-student in collaboration with the Vinnova strategic competence centre for III-nitride technology (C3NiT).

There is also an overall need to strengthen the innovation ecosystem within nanotechnology and deep tech, and we work in close collaboration with RISE (Research Institutes of Sweden), Region Skåne and companies to develop our education and research by engaging on a national and international level.

Many researchers who are part of NanoLund are also active in the research program Mistra Environmental Nanosafety where they study development and production of nanomaterials from a life-cycle perspective. This work will expand through the new thematic collaboration initiative NanoSafe4All initiated by LU, DTU, industry and public authorities.

The unique capabilities of MAX IV and ESS enables us to study important scientific questions concerning the properties of different materials. In close collaboration with the Sustainable Production Initiative (SPI), another Strategic Research Area at Lund University and the Chalmers University of Technology, and major Swedish companies from the metals and manufacturing industry we are exploring new ways for companies to use the large scale facilities together with academic researchers. During the year we successfully applied for beamtimes and the first experiments were performed.

NEW CONCEPTS – NEW IDEAS

Researchers within NanoLund are encouraged to validate how research results can be utilized for new concepts and ideas relevant to society and industry. The Covid-19 pandemic kept the world in a firm grip longer than we could have ever imagined. Among other things the pandemic triggered an increased demand for knowledge about for instance indoor air quality and spreading of nanoparticles such as viruses. The aerosol researchers of NanoLund have been frequent guests in media sharing their research results and offering perspectives on the course of events through the pandemic.

To be able to prevent the rapid spread of the SARS-CoV-2 virus it is important to understand and detect onset of disease. The aerosol researchers Malin Alsved and Jakob Löndahl have been visiting potential patients in their homes bringing a "lab-on-wheels" to be able to measure virus levels before the patient even show symptoms.

This year the NanoLund researchers Martin Hjort, Yang Chen, and Magnus Borgström were awarded the

Martin Adell, Technology Platform Manager at Tetra Pak and Axel Knutsson, Materials Specialist at Alfa Laval at the MAXPEEM beamline at MAX IV synchrotron. Illustrating the synergies obtained when companies are involved in the whole process, from application to design and implementation of an experiment, and in the data analysis. Photo: Filip Lenrick

Lund University and Sparbanken Skåne's prize for future innovations. Their projects are named "Overcoming the shortage of blood stem cell donations with the help of nanotechnology" and "Transparent solar cells: solar cell windows", and are highlighted on p. 12. It is a long journey to take a nanotechnology based invention to market and we are therefore pleased to note that our spin-off companies are successful in attracting funding from different sources such as the prestigious European Innovation Council.

We aim to support innovation and 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. In the following table, you will find short descriptions of what they do and their number of employees to indicate the size of their activities. One of the companies Glo was acquired during the year by the leading California-based company within quantum dot light-emitting materials and technology, Nanosys.

Table 1. Spin-off companies from NanoLund
Spin-off companies from NanoLund (companies in operation by December 2021, in alphabetical order). The number of employees has been deducted from the latest available public yearly report (2020).

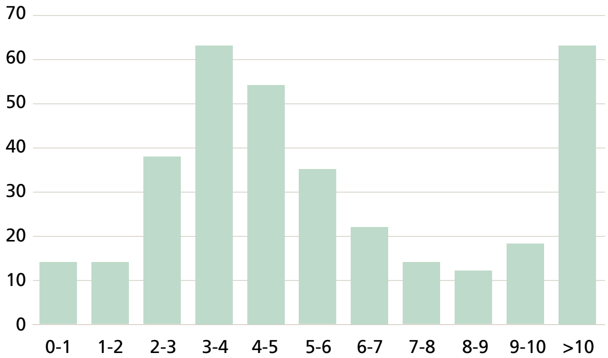
COMPANY		STARTING YEAR	NUMBER OF EMPLOYEES 2020
Acconeer	Develops unique radar solutions based on pulsed coherent radar technology combining extremely low energy consumption with high accuracy.	2011	37
AcouSort	Combines acoustics and microfluidics to separate and sort cells and particles in biological and clinical samples.	2010	12
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	4
AlixLabs	Provides a method to manufacture nanostructures with a characteristic size below 20 nm for the electronics industry.	2019	1
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	17
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	3
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	5
Glo (aquired by Nanosys 2021)	Develops LEDs in the colours red, green and blue using III-nitride-based nanowires.	2003	No available data
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	4
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	6
Obducat	Develops and supplies lithography solutions for production and replication of advanced micro and nanostructures for industrial needs.	1989	40
Spermosens	Develops a diagnostic technology for male infertility aiming to predict the outcome of in-vitro fertilizations.	2019	2
Thyrolytics (aquired by AegirBio 2020)	Develops a diagnostic tool for measuring thyroid hormones in blood.	2018	0
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	6
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

Scientific publications

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 2021, the number of publications was 404.

The quality of our publications remained high, with an averaged journal impact factor (JIF) of 7.15, 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 indicates a healthy mixture of specialized, in-depth research with visionary high-impact studies.

Journal impact factor distribution for NanoLund publications in 2021 (333 of the 352 nanoscience publications have a defined JIF)



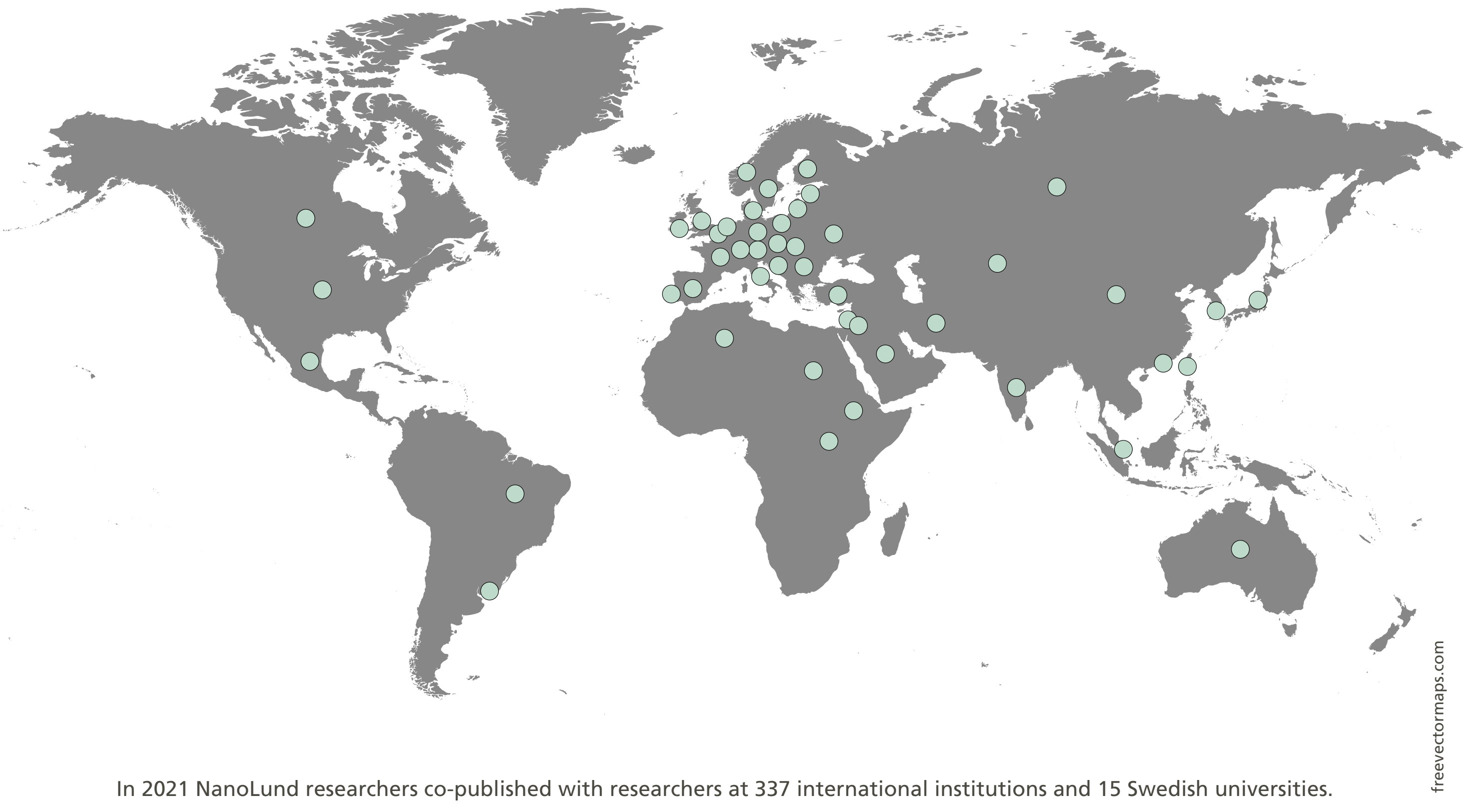
PUBLICATIONS 2021

404 Publications in total

352 Publications directly related to nanoscience

63 Nanoscience publications with journal impact factor > 10

7.15 Average journal impact factor



In 2021 NanoLund researchers co-published with researchers at 337 international institutions and 15 Swedish universities.

NanoLund Awards 2021

NANOLUND AWARD FOR EXCELLENT TECHNICAL AND ADMINISTRATIVE SUPPORT

This award emphasizes the critical importance of the work done by NanoLund administrative and technical personnel, without which none of our research and teaching would be possible. This award recognizes outstanding achievements for technical and administrative personnel in 2021.

Anastasiia Anastasis, Research administrator, Solid State Physics

Daniel Madsen, Research engineer, Centre for Analysis and Synthesis

NANOLUND YOUNG TEACHER AWARD

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 2021 it was presented to:

Jonatan Fast, PhD student, Solid State Physics

Linnea Lindh, PhD student, Chemical Physics

NANOLUND JUNIOR SCIENTIST IDEAS AWARD

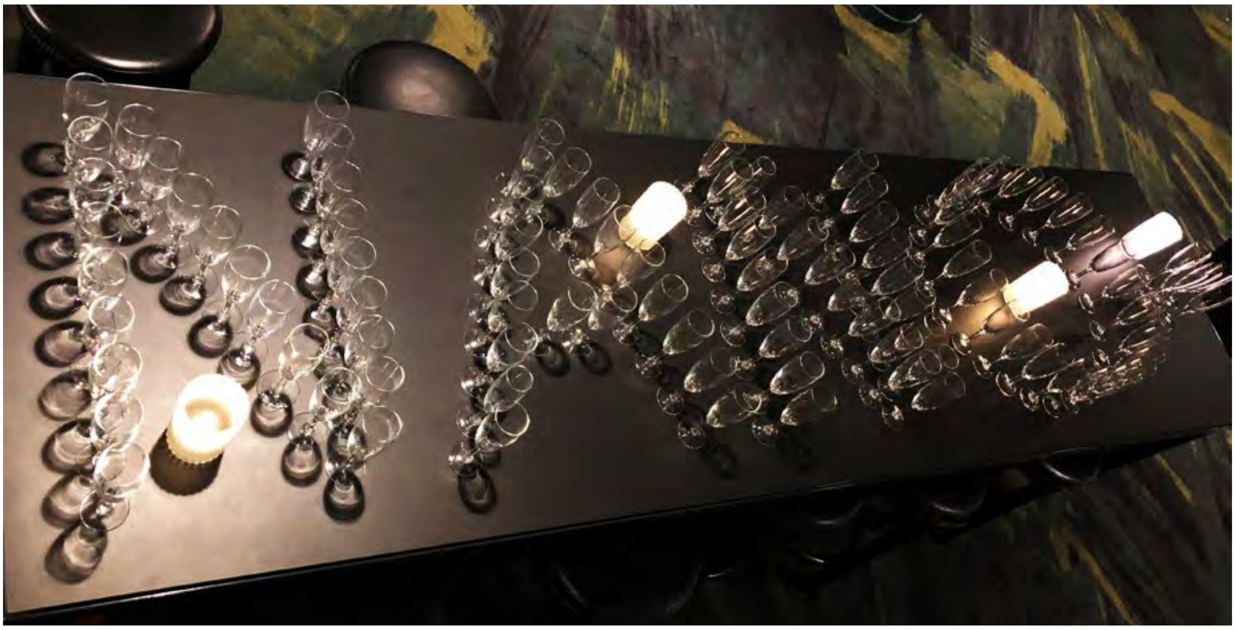
Selection for this award is based on the originality, feasibility, potential impact and initiative of the project as judged across all research areas of NanoLund. Projects for this award are selected among high-quality proposals for novel research projects submitted by master's students, PhD students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

In 2021, 13 project applications were received and evaluated by a group of senior scientists. Three projects were selected for funding by a one-time sum of SEK 100 000 each for research expenses:

Anurag Kawde, LINXS – Towards more efficient water splitting: Charge carrier dynamics in CdSe functionalized Si nanowire photoelectrodes.

Yen-Po Liu and **Zhaojun Zhang**, Synchrotron Radiation Research – Temperature dependent optoelectronic properties studies on the suspending single CsPbBr3 NW device.

Carina B. Maliakka, Centre for Analysis and Synthesis – In-situ TEM investigation of Stranski-Krastanov growth dynamics.



Poster mingle refreshments at the annual meeting. Photo: Evelina Lindén

Outreach – how we are spreading our research results

With nanotechnology we have keys to new solutions for a more sustainable society and a healthier planet. At NanoLund, we work to share our knowledge in order to help address important needs in society and to inspire young people to engage in the development of nanoscience.

The goal of NanoLund outreach activities is to spread information about nanoscience and nanotechnology, including safety and sustainability aspects and opportunities to address important needs in society. This can be done via lab tours, lectures, but also practical exercises. After the lift of the restrictions due to the Covid-19 pandemic, we have seen an increased interest in NanoLund and the Lund Nano Lab. An 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.

In addition, NanoLund's research results have been widely spread during the year through several press releases, interviews in regional news programs, in printed newspapers, and via features on radio and TV. In 2021 NanoLund produced a podcast on how the Covid-19 pandemic has raised the importance of research, with our researchers Sara Thuresson and Jakob Löndahl which was released during Lund University Framtidsveckan.

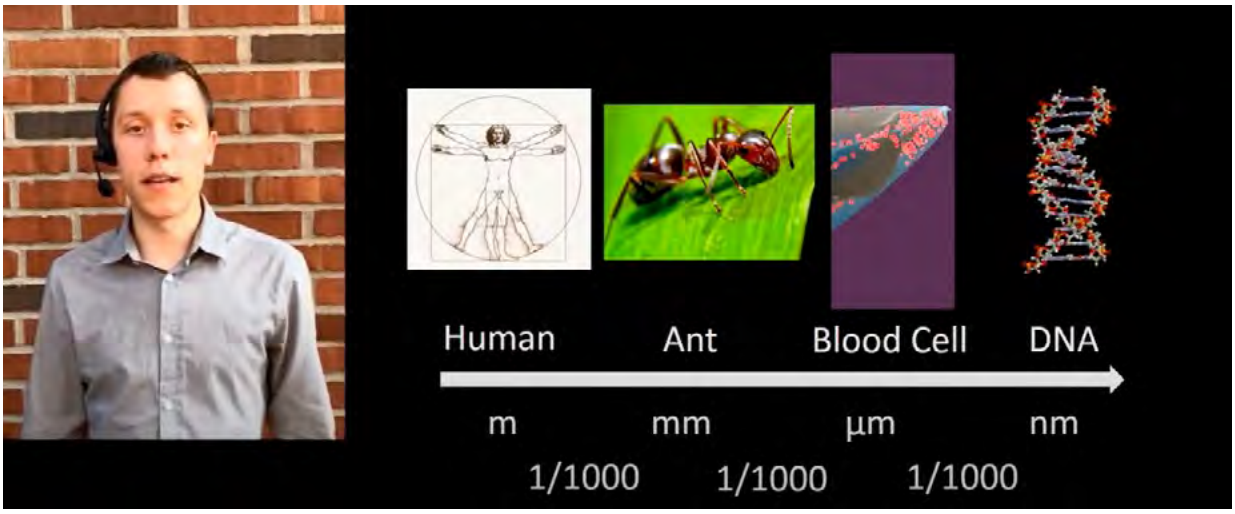
In November the theatre play Den rätta vägen (The right way) concluded their tour around Sweden with a final performance for researchers and staff at the Physics Department. In this Formas funded project, the NanoLund research groups of Tommy Cedervall and Mikael Ekvall have together with Teater Sagohuset toured highschools throughout Sweden with a play and interactive workshop on how we handle new research findings in our everyday lives.

The TechConnect Europe Innovation Conference & Expo aims to connect top applied research and early-stage technologies from universities, labs and startups with industry and investment end-users and prospectors. In 2021, NanoLundians Heiner Linke and Christelle Prinz, were invited key note speakers, as was NanoLund SAB-member Heike Riel. Other invited speakers included NanoLundians Fredrik Höök, Håkan Pettersson, Lars Montelius and Lars Samuelson.

As in previous years, NanoLund participated in Lund municipality's annual Night of Culture, Kulturnatten. The NMT-days at Lund University were in 2021 arranged as a virtual event with Christina Isaxon presenting a popular talk on Friska fläktar och farliga partiklar i luften.

LINKEDIN: Our posts were seen more than 82 000 times and of those 4 438 resulted in people clicking on the links we presented. NanoLund had 2 590 LinkedIn followers at the end of 2021.

TWITTER: 15 tweets were seen 17 100 times.



Screenshot from NanoLund at Kulturnatten.

Education closely connected to world-class research

NanoLund engages in education at all levels, from undergraduate education to professional training for companies. We give specialized courses preparing students for graduate studies, as well as for careers outside the university. An important aspect is to integrate our research infrastructures into education, and we give and develop undergraduate student courses that include Lund Nano Lab, nCHREM as well as MAX IV. Also, we work to share knowledge of nanoscience and nanotechnology with our community through different educational activities for professionals.

NANOLUND STUDENT MEMBERS

NanoLund strives for strong interactions with undergraduate education program at Lund University. At present, approximately 120 undergraduate students from several different education programs are signed up as NanoLund student members. During autumn student events could be arranged again after the pandemic, with the NanoLund student retreat for PhD-students and postdocs in October as a highlight.

UNDERGRADUATE EDUCATION IN NANOSCIENCE

NanoLund and its researcher are actively involved in several educational programs at different faculties at Lund University. The Engineering Nanoscience Program at the Faculty of Engineering is the only Master's degree program in Sweden with nanoscience as a consistent theme throughout all five years. The program 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 program. In autumn 2021, 40 students started the program; 14 of whom are women. Like the rest of society, the Nanoscience program has adapted to the Covid-19 pandemic, with most of the teaching activities being performed on-line.

ENGINEERING NANOSCIENCE STATISTICS 2021

40	students started
14 (35%)	women among started students
26 (65%)	men among started students
19.58	grade point average needed for high-school students
32	students graduated
10 (31%)	women among graduated students
22 (69%)	men among graduated students

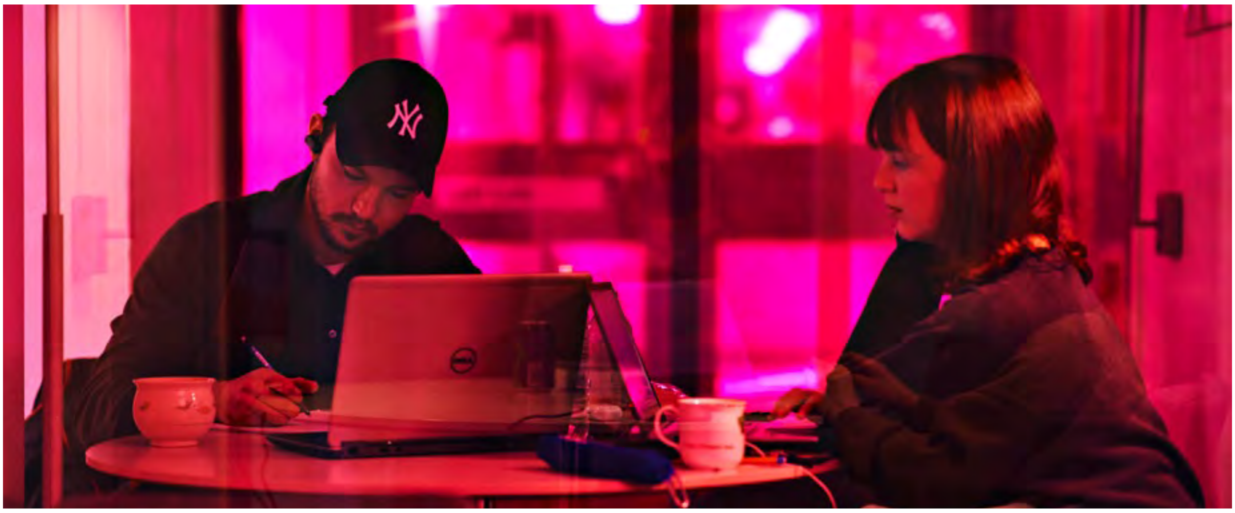
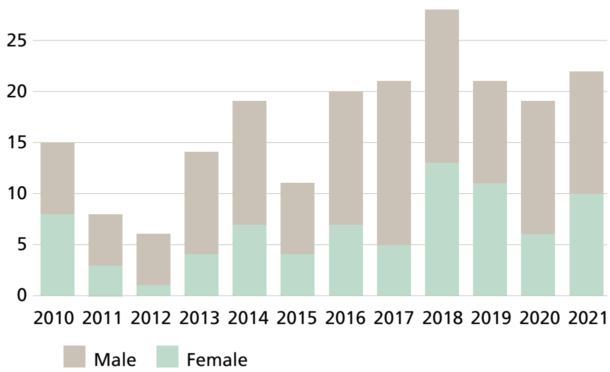


Photo: Johan Persson

The coming generation of nano-scientists

NanoLund is Sweden's largest research environment for interdisciplinary nanoscience and nanotechnology. In 2021, we engaged more than 150 PhD students, in sciences ranging from engineering to natural sciences and medicine. The PhD students constitute roughly one-third of the staff engaged in NanoLund and are an important and integrated part of the research conducted. 22 NanoLund PhD-students defended their thesis in 2021.

NanoLund PhD-thesis (per gender) 2010–2021



GenerationNano is a Marie Curie Cofund doctoral program offering exciting research at the forefront of nanoscience, full-time employment for four years, an international network of cooperation partners and a comprehensive course program. In total 14 doctoral students have been recruited in the areas materials science, quantum physics or nanobiology. The students were recruited following the MSCA mobility requirements and will be educated in close interaction between academia, research institutes, commercial enterprises, and unique large-scale research infrastructures. This creates excellent opportunities to engage in interdisciplinary approaches to be able to tackle the interdisciplinary approaches needed to bring nanotechnology to the marketplace and to educate the workforce that will help solve the European Societal Challenges and the UN Sustainable Development Goals.

Claudiu Bulbucan	Synchrotron Radiation Research	Characterization of Magnetic Nanoscale Systems: From Molecules to Particles and Self-Assembled Chains
Marija Dubackic	Physical Chemistry	alpha-synuclein: amyloid fibrils and interactions with lipid membranes
Rebecca Frankel	Physical Chemistry	Co-assembly of proteins and lipids
Nadja Gustavsson	Medical Microspectroscopy	On the nature of mixed neurodegenerative amyloidopathies
Alex Arash Sand Kalaee	Mathematical Physics	The Struggles of Light Bound in Matter
Veronica Lattanzi	Biochemistry and Structural Biology	Amyloid β peptide: from monomer solubility to fibril structure
Egor Leshchenko	Solid State Physics	Kinetic and thermodynamic modelling of ternary nanowire growth
Jun Li	Chemical Physics	Effects of Environment on Charge Recombination in Organo-Metal-Halide Perovskite Observed by Photoluminescence Microscopy and Spectroscopy
Anette Löfstrand	Solid State Physics	Block Copolymer Nanolithography for Sub-50 nm Structure Applications
Erik Mårtensson	Solid State Physics	Kinetic and Thermodynamic Modeling of Nanowire Growth
Karolina Mothander	Physical Chemistry	Grazing incidence small angle neutron scattering as a tool to study curved biomembranes on nanostructured surfaces
Juanzi Shi	Chemical Physics	Nanoscale organization of luminescent materials and their polarization properties investigated by two-dimensional polarization imaging
Sudhakar Sivakumar	Solid State Physics	Understanding and Optimization of III-V nanowire growth in Aerotaxy
Zhengjun Wang	Chemical Physics	Coherent Multidimensional Spectroscopy: Development of Efficient Data Acquisition and Analyses of Quantum Dot 2D Spectra
Lukas Wittenbecher	Synchrotron Radiation Research	Time-Resolved Photoemission Electron Microscopy: Development and Applications
Hailiang Xu	Centre for Analysis and Synthesis	Study the Influence of Quantum Interference on the Electrical Conductance and Thermoelectric Properties of Molecular Junctions
Weronica Linpe	Synchrotron Radiation Research	Using Light to Probe Surface Electrochemical Processes
Erik Malm	Synchrotron Radiation Research	Numerical and experimental aspect of coherent lensless imaging
Irene Geijselaers	Solid State Physics	Optical studies of crystal phase heterostructures
Christina Andersen	Ergonomics and Aerosol Technology	Cookstoves, Candles, and Phthalates – Real Time Physicochemical Characterization and Human Exposure to Indoor Aerosols
Alireza Honarfar	Chemical Physics	Charge Carrier Dynamics in Novel Solar Materials
Johan Larsson	Physical Chemistry	Tailoring the selfassembly, interfacial properties and rheological behaviour of sugarbased surfactants

A selection of cover pages from NanoLund thesis 2021.

Aerosols – small, airborne particles – are studied in the laboratory by NanoLundians Sara Thuresson and Malin Alsved. Photo: Kennet Ruona

Funding

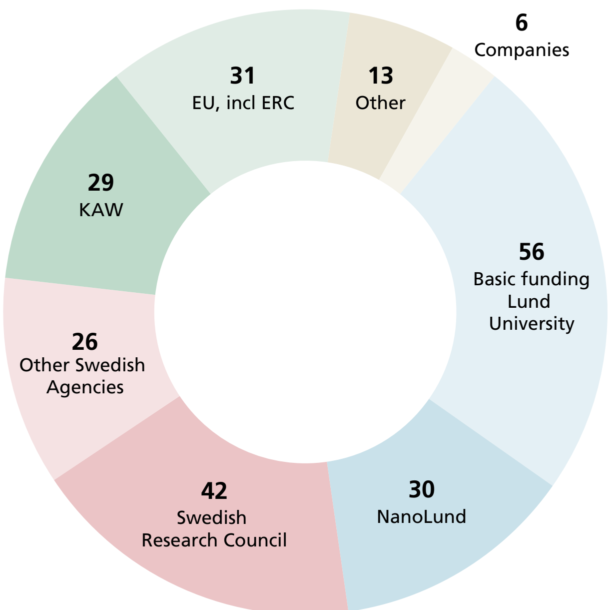
NANOLUND INCOME SOURCES FOR 2021

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 2021 the total income for NanoLund was MSEK 233. This is an increase of MSEK 17 compared to 2020 and is mainly due to an increase in the amount of external funding our researchers have won in competitive calls. MSEK 86 came from Lund University, of these MSEK 30 are strategic research area funding for NanoLund. MSEK 177, corresponding to 63% of the total income was external funding won in competitive calls. See the diagram below for the distribution of funding from individual income sources.

NanoLund income sources 2021 (MSEK)



FUNDING HIGHLIGHTS

NanoLundians are active and successful in applying for externally funded grants, and many holds highly prestigious grants. In 2021 NanoLund grantees included:

- 7 active ERC grants (in total 13 NanoLundians have received ERC grants)
- Participation in 16 EU-projects
- Coordination of 2 of our 16 EU-projects
- 4 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, from the Swedish Foundation for Strategic Research, SSF
- 1 Ingvar Carlsson Award from SSF
- 1 Strategic Mobility Grant from SSF

Thanks to our funders

AFA Insurance

Alzheimerfonden

Cancerfonden

Carl Tryggers stiftelse för vetenskaplig forskning

Crafoord Foundation

Danish Council for Strategic Research

Danish Hydrocarbon Research and Technology Center (DHRTC)

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

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

FQXi – Foundational Questions Institute

Hagbergs stiftelse

Hjärnfonden – the Swedish Brain Foundation

Independent Research Fund Denmark

KMA – Stiftelsen Kronprinsessan Margaretas Arbetsnämnd för synskadade

Knut and Alice Wallenberg Foundation

LMK-stiftelsen

Lund University

Magnus Bergvalls Stiftelse

Maja och Erik Lindqvists Forskningsstiftelse

Mats Paulssons Stiftelse för forskning, innovation och samhällsbyggande

MISTRA, the Swedish Foundation for Strategic Environmental Research

Novo Nordisk Foundation

Office of Naval Research

Olle Engkvists stiftelse

Region Skåne

Royal Physiographic Society of Lund

Ruth och Nils-Erik Stenbäcks stiftelse

Sanofi

Sida – the Swedish International Development Cooperation Agency

STINT – the Swedish Foundation for International Cooperation in Research and Higher Education

Swedish Energy Agency

Swedish Environmental Protection Agency

Swedish Foundation for Strategic Research, SSF

Swedish Heart-Lung Foundation

Swedish Research Council

Swedish Water Research

Swedish Work Environment Authority

Sydvatten AB

Vinnova

Volkswagenstiftung

Åhléns-stiftelsen

Åke Wibergs stiftelse

Photo: Dmitry Suyatin

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This Annual Report 2021 for the NanoLund research environment at Lund University presents scientific, educational, outreach and public impact highlights, progress, data, and trends for and up to 2021. This report is based on material and data compiled and edited by the staff of NanoLund, in particular: **Mirja Carlsson Möller,** Coordinator | **Evelina Lindén,** Communication | **Anna-Karin Alm,** External Relations Officer | **Gerda Rentschler,** Project Coordinator | **Anneli Löfgren,** Administrative Director | **Anders Mikkelsen,** Director | **Maria Messing,** Deputy Director

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