



LUND
UNIVERSITY

NANOLUND

ANNUAL REPORT 2018



Unique Opportunities Ahead

BUILDING THE FUTURE NANOLUND ON OUR CORE VALUES: OPENNESS, ENTHUSIASM AND PIONEERING

NanoLund is a value-driven organization that builds on a strong culture of openness, enabling us to collaborate broadly and easily. Many of our projects that have the highest impact draw on expertise and excellence in multiple disciplines. A key success factor is our wide sharing of equipment and resources, that allows everyone – from PhD students to new faculty – to access an incredibly wide range of capabilities within characterization, fabrication and modelling, from the day they start working with us.

The year 2018 brought new developments and successes ranging from groundbreaking basic science via pioneering experiments performed at the still very new synchrotron MAX IV, to prize-winning innovations in some of our spin-off companies. We continue to be enthusiastically active in outreach and education, and I am particularly happy to welcome the 120 undergraduate student members who joined NanoLund since 2017.

Another important 2018 milestone was Lund University's formal decision to establish a presence of university institutions in Science Village, including research groups who are part of NanoLund. Lund University's first building in Science Village will be the new Lund Nano Lab, which is urgently needed because we have been outgrowing our current facilities for nanofabrication. The new lab will be of national and regional interest as a state-of-the-art, key-enabling resource within the innovation community Science Village, for both academic and industrial users. To make the lab possible, additional funding is needed from many sources, inside and outside of the university.

Maintaining a close link to education on all levels is vital for the future excellence of NanoLund and we keep pushing for undergraduate education to be included as a natural part of Lund University's vision for a Science Village campus.

A key factor in our planning for Science Village is to identify optimal synergies with MAX IV, ESS, and other strong research areas. These synergies were also the theme of our 2018 Annual Meeting and they are central to our ongoing work for NanoLund's next strategic plan. The next five to ten years will be of transformative nature for NanoLund, and we are excited to have a fantastic and unique opportunity to shape our future through the new lab and key recruitments.

We are grateful to all of our staff and partners, inside and outside the university, for your ongoing support and contributions, and we look forward to continuing this exciting journey together with you.

Heiner Linke
Director



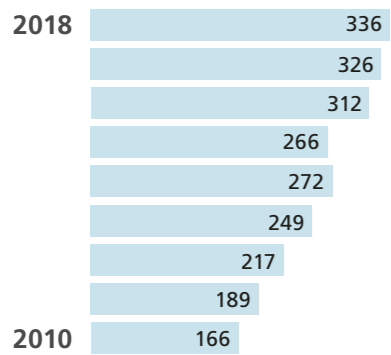
Heiner Linke, NanoLund Director.
Photo: Kennet Ruona

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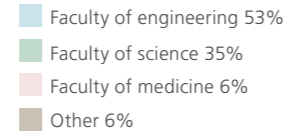
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2018 in brief

STAFF



FACULTY AFFILIATION



CURRENT NUMBERS

- 186 MSEK Funding 58% external
- 6.2 Average impact factor
- 21 Contributing LU divisions
- 58 Faculty members
- 36% Women
- 138 Phd students
- 120 Undergraduate student members

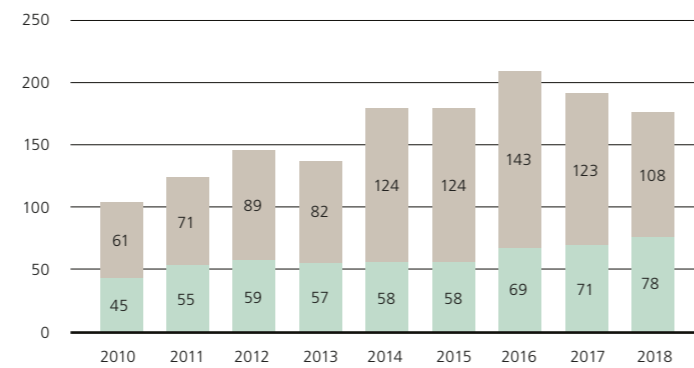
In 2018, NanoLund:
 Included 9 ERC Awardees
 Participated in 13 EU projects
 Coordinated 4 EU projects
 & 1 Marie Skłodowska-Curie Individual Fellowship

HISTORY

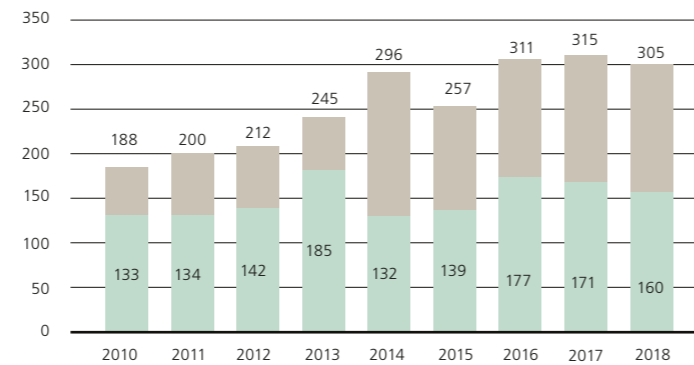
- 1988 The Nanometer Structure Consortium (nmC) is initiated
- 1995 SSF funds nmC with several major grants until 2012
- 2000 Major nanowire research programme initiated
- 2003 Undergraduate education programme in Engineering Nanoscience starts
- 2007 Inauguration of Lund Nano Lab
- 2010 Strategic Research Area funded by the Swedish Government
- 2015 nmC becomes NanoLund, the Center for Nanoscience at Lund University

TRENDS

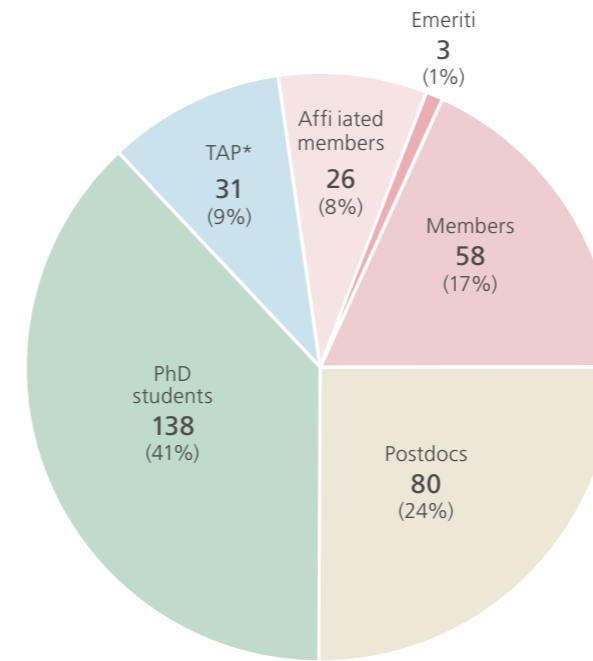
Funding over time (MSEK)



Total number of publications



People



People per personnel category 2018

PERSONNEL & MEMBERSHIP

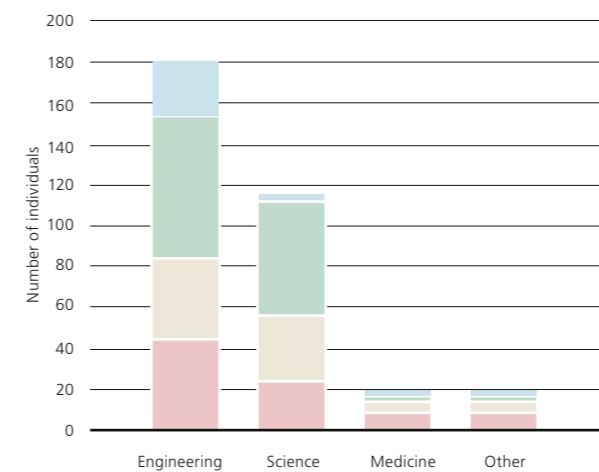
The number of individuals involved in NanoLund is roughly the same in total for all categories in 2018 compared to 2017. The average annual level of engagement in NanoLund overall is about 60%, which corresponds to 208 full-time equivalents. Looking at the long-term trends, we note that the number of PIs has been approximately constant for the past nine years, while all other categories have been growing. This indicates a healthy growth of the individual research groups and infrastructures.

Gender Balance 2018

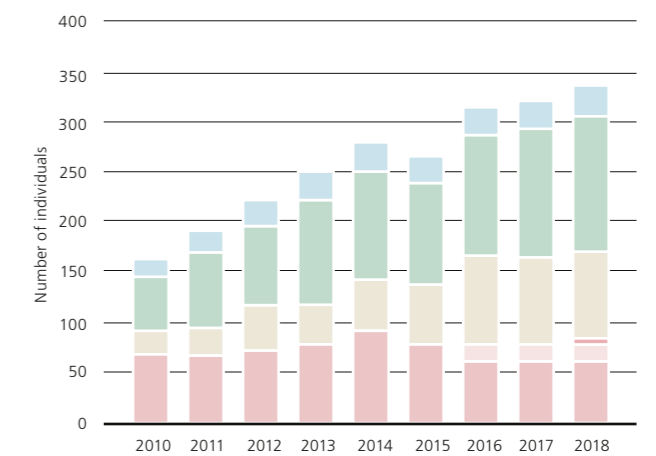
NanoLund strives for gender balance and being a diverse and inclusive workplace. Current stats are:

PIs:	24% women	76% men
Postdocs:	26% women	74% men
PhD students:	46% women	54% men

NanoLund people by faculty, 2018



Personnel trends 2010-2018



LEGEND

(Applies to all figures on this page)

- PhD students
- Postdocs
- TAP
- Principal investigators:
 - Members
 - Affiliated members
 - Emeriti

* TAP = Technical and Administrative Personnel

Selected highlights per research area

QUANTUM PHYSICS

Exploring new quantum physics to enable future devices with enhanced performance

2018 highlight: A Szilard engine enables the conversion of information into useful work. Can quantum phenomena enable better work output compared to the classical original? We find that the answer is yes for attractively interacting bosons. Unusual for the quantum world, the machine performs best at finite temperature, indicating a constructive role of thermal effects.

J Bengtsson et al, *Physical Review Letters* 2018, 120 (10), 100601

MATERIALS SCIENCE

Atomic level characterization, understanding and design of nano-materials

2018 highlight: In a series of papers, two-component nucleation theory is used to understand the multi-element balance between seed particle and nanowire composition. As the precise alloy composition allows the tuning of nanowire properties such as a light emitting colour, their fundamental understanding of nanoscale compound formation allow the design of nanowires with properties perfectly tailored to their use.

ED Leschenko et al, *CrystEngComm* 2018, 20 (12), 1649

EXPLORATORY NANOTECHNOLOGY

Pushing the boundaries of nanoscale manufacturing

2018 highlight: The chemical reactions at the surface during the first cycle of atomic layer deposition (ALD) is directly observed under realistic synthesis conditions using an electron spectroscopy technique, available at the MAX IV synchrotron in Lund. ALD enables the ultrathin, highly controlled oxide layers that are found in all modern electronics. This study provides new understanding of how the efficiency of the self-cleaning process and the quality of the semiconductor-oxide interface can be controlled by initial molecular adsorption processes.

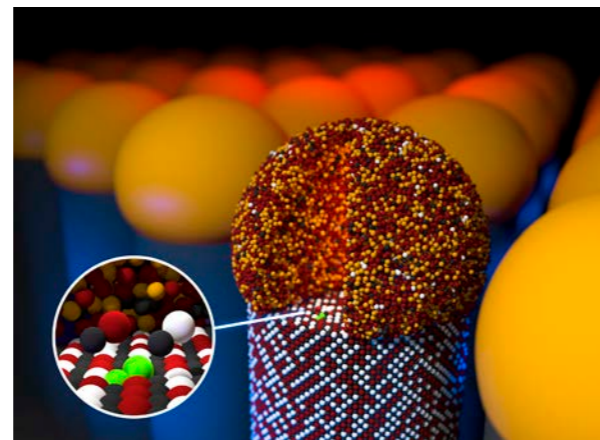
R Timm et al, *Nature Communications* 2018, 9 (1), 1412

NEURONANOSCIENCE AND NANOBIOLOGY

Tools for investigating biological cells, one by one

2018 highlight: Bacteria, such as *Streptococcus pneumoniae* can change shape, and this appears to be related to the degree and type of damage they can cause. We have developed a microfluidic sorting device that fractionates a mixed bacterial population into subpopulations based on their shape, allowing further biomedical studies of putatively functional subpopulations.

JP Beech et al, *Analytica Chimica Acta* 2018, 1000, 223



Nucleation-limited composition of ternary III-V nanowires forming from quaternary gold based liquid alloys.

NANOSAFETY

Understanding how man-made nanostructures affect humans and nature, and to ensure a safe use of nanotechnology

2018 highlight: Work environments harbor the greatest risk of exposure to manufactured nanoparticles. We perform biological monitoring of workers exposed to nanoparticles including nanowires. The overall aims are to assess a program for preventive health monitoring, and to determine whether current exposure level causes early measurable health effects.

N Ali et al, *Clin Proteomics* 2018, 15 (1), 20

NANOELECTRONICS AND PHOTONICS

Using fundamental physics for novel devices powering our information society

2018 highlight: The first nanowire photodetector for long-wavelength infrared radiation has been realized this year. Intriguing optical characteristics are explained by excitation of optical modes in the nanostructured photonic crystal in the detector. The advantage is the engineered broadband infrared sensitivity in a detector design, compatible with the standard silicon electronics platforms.

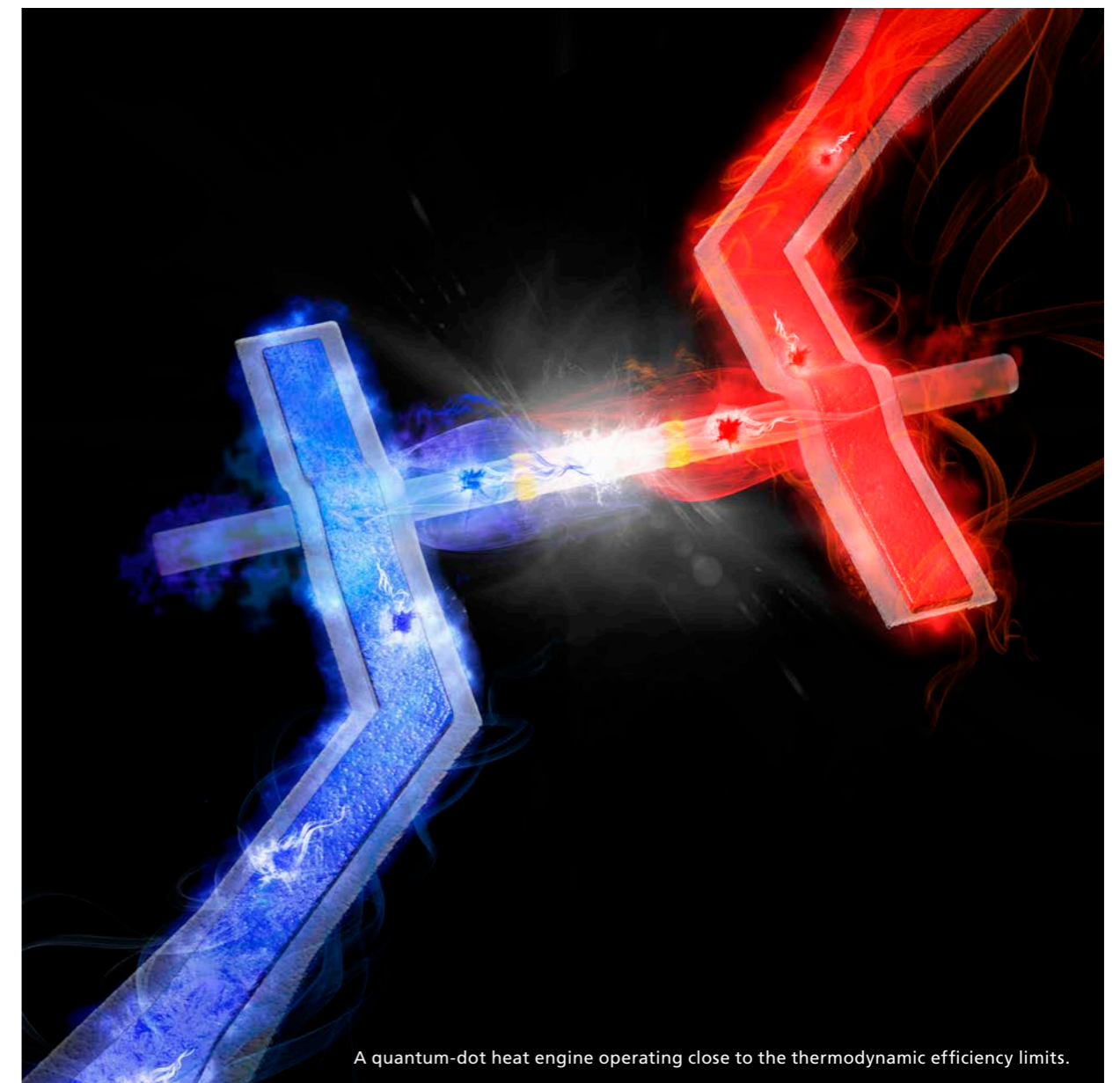
M Karimi et al, *Nano Letters* 2018, 18 (1), 365

NANOENERGY

Nanoscale phenomena for more efficient energy conversion and harvesting

2018 highlight: Even the most modern power stations need steam turbines to generate electricity. Is it possible to convert heat into electricity directly and efficiently? The answer is yes: by using quantum dots to filter out the electrons that convert heat most optimally, we achieved the same efficiency as the best power stations, but without the need for a turbine.

M Josefsson et al, *Nature Nanotechnology* 2018, 13 (10), 920



A quantum-dot heat engine operating close to the thermodynamic efficiency limits.

ANNE L'HUILLIER JOINS THE NATIONAL ACADEMY OF SCIENCES OF THE USA

Anne L'Huillier, as the only physicist in Sweden, has been elected as a member of the National Academy of Sciences of the USA (NAS). Members are elected to the NAS in recognition of their distinguished and continuing achievements in original research. Membership is a widely accepted mark of excellence in science and is considered one of the highest honors that a scientist can receive. Current NAS membership totals approximately 2,300 members



Anne L'Huillier

and nearly 470 foreign associates, of whom approximately 190 have received Nobel prizes. A maximum of 84 members may be elected annually and members must be U.S. citizens; non-citizens are elected as foreign associates, with a maximum of 21 elected annually. There is one more member of NAS at Lund University, Anders Björklund (Cellular and Molecular Neuroscience), and seven more in Sweden.

DONATION FOR EQUIPMENT FOR LED RESEARCH

LMK Stiftelsen has decided to support NanoLund with a donation of 5 MSEK for equipment for fabrication and characterisation of nanostructures. The donation is specifically motivated by research led by Lars Samuelson on light emitting diodes (LEDs) for energy-efficient, human-centered lighting. The equipment will be operated as part of our user facility Lund Nano Lab and will also be useful for a broad range of basic and applied research. This important support is absolutely essential for our ability to stay at the forefront of nanoscience and to develop the nanotechnology of the future.

LUMINESCENT IRON MOLECULE MAY RESULT IN CHEAPER SOLAR ENERGY

NanoLund researchers, in collaboration with researchers from Uppsala University and University of Copenhagen, have designed an iron complex which has shown to be luminescent and to have charge-transfer capabilities. This opens up for the possibility of replacing the expensive and rare metals such as

ruthenium, osmium and iridium with iron in metal complexes of photocatalysts. The findings were published in Science (DOI: 10.1126/science.aau7160) and have attracted a lot of interest.

LIVE MONITORING OF NANOWIRE GROWTH

A new transmission electron microscope with up to 50 million times image magnification has moved in at Kemicentrum. To start with, it will be used by researchers within NanoLund who can get full control of the growth of materials using the feature of live videos resolving individual atoms during growth. The new environmental transmission electron microscope (ETEM) is financed by the Knut and Alice Wallenberg Foundation and was inaugurated April 12th 2018 with a full day symposium.

HIGHLY CITED RESEARCHERS 2018

The list of Global Highly Cited Researchers 2018 recently released by Clarivate Analytics recognizes world-class researchers selected for their exceptional research performance, demonstrated by production of multiple highly cited papers that rank in the top 1% by citations for field and year in Web of

Science. On the list are 62 researchers from Sweden of which 9 are from Lund University. Two of these are NanoLund researchers: Sara Snogerup Linse and Lars Samuelson. Both were identified in the new cross-field category introduced 2018 to recognize researchers with substantial influence in several fields.

NANOSAFETY FEATURED BY SWEDISH RADIO

Swedish Radio broadcasted a feature on nanosafety – Hur farlig är nanotekniken? The program involved NanoLund scientists Christina Isaxon, Knut Deppert, Maria Hedmer and Tommy Cedervall.

A short version was also brought in the Science news program Vetandets värld.

BEST POSTER AWARD TO SEVERAL PHD-STUDENTS

Four PhD-students have been recognized with Best Poster awards at different international conferences: Irene Geijsselaers at the 34th International Conference on the Physics of Semiconductors (ICPS 2018) in Montpellier, France; Calle Preger at the Aerosol Technology Conference (AT2018) in Bilbao, Spain; and both Malin Alsved and Louise Green at the 10th International Aerosol Conference in Saint Louis (IAC 2018), USA.

WORKSHOPS ON IMAGING AND MICROSCOPY

During 2018, two large workshops on microscopy and imaging with international speakers and participants have been arranged by NanoLund researchers. A Workshop on Superresolution Techniques was held in Lund, May 28th–29th with 85 participants. A Marcus Wallenberg symposium on Tailored surfaces in operando conditions was held in Ystad, June 11th–14th, with 80 participants.

JESPER WALLENTIN WINS ERC STARTING GRANT

NanoLund researcher Jesper Wallentin has been awarded an ERC starting grant.

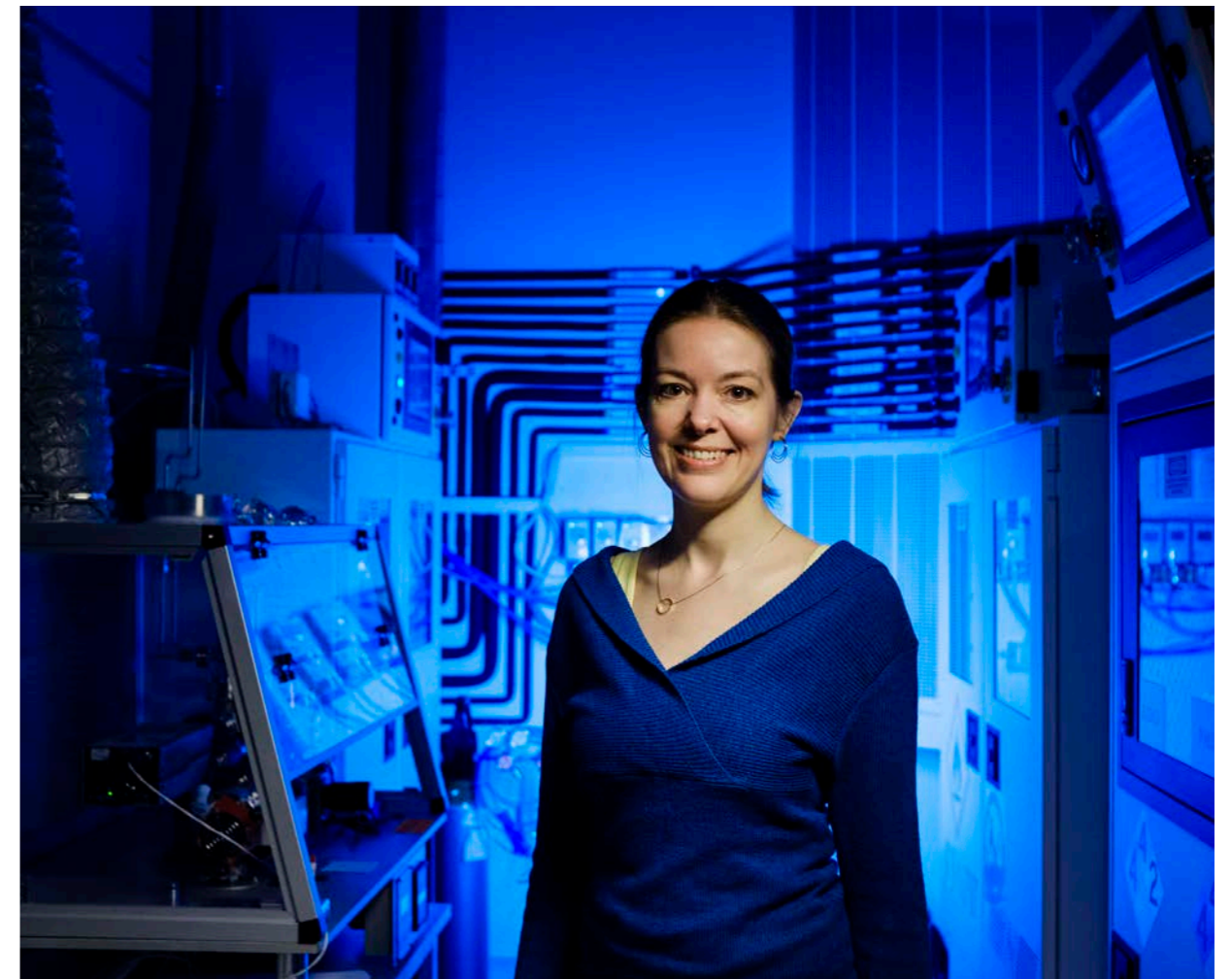
The project will investigate whether semiconductor nanowires can be used as high-resolution X-ray detectors. Wallentin's group have some initial results that show that they can get a measurable electric current from single nanowires that are exposed to X-rays.

Long term, the hope is that nanostructured X-ray detectors could be used for X-ray microscopy with much better resolution than current systems.

The grant will finance one PhD-student, one postdoc, part of Jesper Wallentin's salary and an X-ray lab that will allow research to go from initial results to a full study of the potential of nanowires as X-ray detectors.



Jesper Wallentin



PRIZES FOR KIMBERLY DICK THELANDER

Professor Kimberly Dick Thelander from the Department of Physics has been awarded both the 2018 Edlund Prize and the Lindbomska award from the Royal Swedish Academy of Sciences, for her cutting-edge research on new semiconductor crystal phases in nanowires.

Kimberly Dick Thelander
Photo: Tom Wall

2018 SCIENTIFIC TALKS

67 Invited Talks, of which

10 Keynote & Plenary

INVITED TALK
MRS Spring Meeting 2018,
Phoenix, USA

Jesper Wallentin

Using X-ray beams as in operando pump and probe of single nanowire devices



INVITED TALK
Nanowire Week 2018,
Hamilton, Canada
Christelle Prinz
Bioapplications of nanowires



INVITED TALK
6th European Conference on Crystal Growth,
Varna, Bulgaria
Jonas Johansson
Understanding the composition of epitaxially grown ternary III-V nanowires

INVITED TALK
MRS Fall Meeting 2018,
Boston, USA

Heiner Linke

Thermal-to-electric energy conversion near ideal efficiency limits and its potential application to hot-carrier solar cells



INVITED TALK
MRS Spring Meeting 2018,
Phoenix, USA

Maria Messing

Aerosol generated nanoparticles and its applications



INVITED TALK
MRS Spring Meeting 2018,
Phoenix, USA

Joachim Schnadt

Real-time monitoring of the chemistry of atomic layer deposition by ambient pressure x-ray photoelectron spectroscopy



INVITED TALKS
MRS Spring Meeting 2018,
Phoenix, USA
Nanowires for tandem junction solar cells

MRS Fall meeting 2018
Boston, USA

Nanowires for tandem junction solar cells

Magnus Borgström



INVITED TALK
International Conference on Coherent Multi-dimensional Spectroscopy,
Seoul, South Korea

Donatas Zigmantas

Using multidimensional spectroscopy to determine the origin of coherence signals in photosynthetic complexes



INVITED TALKS
Gordon Research Conference, 2018 : Hybrid Electronic and Photonic Materials and Phenomena,
Hong Kong, China

Photoexcitation dynamics in perovskite solar materials

Tõnu Pullerits

MRS 2018,
Boston, USA

Ultrafast spectroscopy of semiconductor nanostructure solar cells



KEYNOTE
19th International Conference on Metalorganic Vapor Phase Epitaxy, IVMOCP-E-XIX,
Nara, Japan

Lars Samuelson

MOVPE growth and applications of III-V and III-nitride nanowires



INVITED TALK
45th Conference on the Physics and Chemistry of Surfaces and Interfaces,
Kona, Hawaii, USA

Erik Lind

III-V Nanowire devices : a 3D toolbox with contact, interface and heterostructure engineering



INVITED TALK
Photonics West 2018,
San Francisco, USA

Andreas Wacker

Trends for terahertz quantum cascade lasers fabricated in different labs

INVITED TALK
Gordon Research Conference : Electron Donor-Acceptor Interactions,
Newport, USA

Petter Persson

Towards unconventional charge-transfer systems for solar energy applications

LEGEND

● Invited Talks

NanoLund visibility worldwide

NanoLund members work hard to disseminate scientific results. In 2018 we have collectively been to 19 different countries presenting our scientific work in nanoscience. A few selected talks are highlighted here.

Sharing knowledge, ideas and innovations



Photo: Kennet Ruona

The core values of NanoLund (Openness, Enthusiasm and Pioneering) are guiding the important work to share knowledge of nanoscience and nanotechnology with our community. Outreach activities, performed in many shapes and forms, by researchers and students communicate new scientific results and achievements to the general public. But it is equally important to inform and inspire key stakeholders to engage and explore the potentials of nanoscience and nanotechnology together with us.

NEW CONCEPTS - NEW IDEAS

The research performed within NanoLund is advancing fundamental science in different areas. The results are explored and new technologies are created to address challenges and needs within society. Researchers within NanoLund are encouraged to validate new concepts and ideas, and since the beginning in 1988 the environment has contributed to the start of as many as 27 companies. The core of NanoLund's success in pushing technologies to market derives from the focus on synthesis, production and application of tailored semiconductor nanostructures. These can then be used in various areas such as optoelectronics (light-emitting diodes, solar cells and infrared detectors) and life sciences (nano/micro fluidic sorting of cells, single-cell probes and neuronal interfaces).

2018 has been as successful year for many of the companies spun out of NanoLund, and we are proud to present a few examples of good news on the following page. In addition, two brand new companies were added to the extended

family of NanoLund. Thyrolytics AB develops diagnostic tools for measuring thyroid hormones in blood and Spermosens AB develops a diagnostic technology for male infertility aiming to predict the outcome of in-vitro fertilizations.

COLLABORATION WITH INDUSTRY

One long-term strategic aim is to contribute to a nanomaterials-based industry in Sweden. Companies in different sectors have an interest in collaborating with NanoLund and some of them are also users of the facilities within the Lund Nano Lab. Others are engaged in different kinds of research collaborations, such as the innovative doctoral programme PhD4Energy funded by the European Union. The programme combined high-level, interdisciplinary research with an extensive secondment programme. When the programme ended in 2018, 12 doctoral students had graduated. A key feature was the direct input of industry leaders in planning the courses, aiming to enhance employability and tech-transfer. In addition to scientific skills the students developed transferable skills such as innovation management, entrepreneurship and leadership. All students practiced their skills doing internships, of which eight were done in industry, two in non-profit institutions, one in a governmental organization and one at a major research infrastructure.

2018 SELECTED INNOVATIONS

ACOUSORT

Acousort launched the table-top research tool, AcouWash, which was then selected as one of the Top 10 innovations of 2018 by the life science journal The Scientist. The company AcouSort was established in 2010 based on the concept that ultrasound in combination with microfluidics can be used to migrate cells and particles. A phenomenon called acoustofluidics. The technology can be used to separate, wash and enrich cells, exosomes and other biological particles for research and diagnostics.

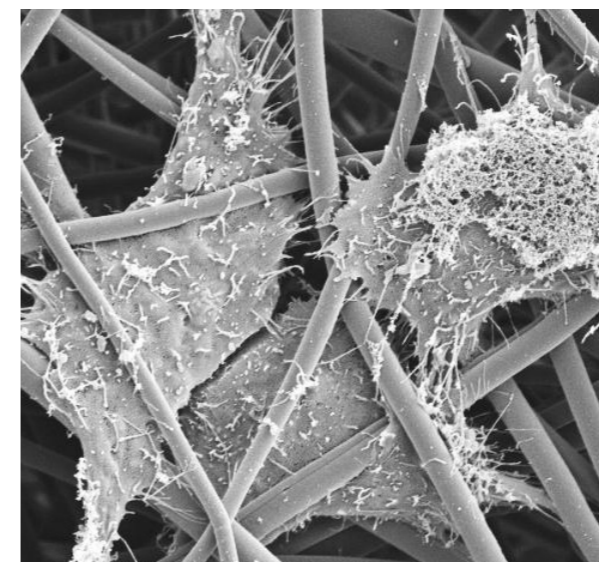
GLO

Glo reached a major goal: after eight years in development the company showcased a series of functional demos and prototypes at the CES conference in Las Vegas, the world's gathering for those doing business in consumer technologies. Glo AB was established 2003 in Lund, aiming to develop light-emitting diodes (LEDs) using III-Nitride-based nanowires. Micro-LEDs offer higher brightness and better power efficiency than existing display technologies and is expected to be the future choice for smart watches, mobile phones and larger displays. In 2010 R&D and product development was established in California, USA.

Right: Glo microLED-displays offer 10x more brightness and 5x better power efficiency with equal or better color quality than current technology. Glo's 1.5" 264 ppi microLED display on LTPS backplane, next to a product offering currently in the market. (Photo: Courtesy of Glo AB)

“While the function of this invention is simple, its capacity to handle small sample volumes at relatively low shear rates is an attractive option for intermittent sampling and analysis of cells during process development and manufacturing protocol optimization.”

Professor Krystyn Van Vliet, member of the judging panel.



CELLEVATE

Cellevate secured 5 million SEK in their third funding round and are ready to scale up marketing and sales of their next generation cell culture systems. The company was founded in 2014 and emanates from a project during a course in the Engineering Nanoscience program where the students investigated effects of nano-topographies on cell cultures. Based on the findings the students, in collaboration with researchers, developed a patented process that combines centrifugal spinning with electrospinning. The result is 3D-scaffolds of fibers that mimics the body's native extracellular matrix – the collagen and elastin fibers – and is thus a good representation of an in vivo environment. The company has then applied the nanomaterial in a product line for basic biological- and pharmaceutical research.

Left: The nanofibre based cell culture system (3D-NanoMatrix) is available off the shelf or custom made. (Photo: Courtesy of Cellevate AB)

Infrastructure

THE LUND NANO LAB (LNL)

NanoLund is the host of and responsible for LNL, an open access state-of-the-art scientific nanofabrication facility. LNL trains about 100 students per year, is integrated in the national facility MyFab, and is also (together with nCHREM) part of the European NFFA-EUROPE distributed nanofoundry and nano-analysis infrastructure. LNL has an epitaxy lab with advanced tools for 'bottom-up' growth of III-V semiconductor epitaxial layers, and nanostructures. It also has a process lab with tools for 'top-down' fabrication and characterization of nanostructures.

KEY FEATURES OF LNL ARE:

- Fabrication and analysis of nanometer-scale structures
- Integration between epitaxy and processing
- Open cleanroom facility for academic research and companies
- 650 m² ISO 5-7 cleanrooms for cutting edge nanofabrication

2018 LNL STATISTICS

53651	Hours booked	27	External users
151	Active users	90	Total tools, of these
129	University users	68	tools are bookable



Maria Huffman, Lab Director, LNL.
Photo: Kennet Ruona



nCHREM - NATIONAL CENTER FOR HIGH-RESOLUTION MICROSCOPY

State-of-the-art tools for Electron Microscopy

The nCHREM facility is situated within the Chemical Center at Lund University and has state-of-the-art tools for electron microscopy. We offer expertise in imaging, element analysis, and sample preparation for a wide variety of sample types. The nCHREM also provides equipment for element 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 chips. We also give advice how to best prepare samples and troubleshooting for other facilities. The active time on the available instruments is well distributed between many different users and lines of research within Lund University, external users and teaching.

LUND NANO CHARACTERISATION LABS

NanoLund possesses an extremely wide range of world-class characterization techniques ranging from microscopes capable of single-atom imaging to facilities for telemetric monitoring of animals. These characterization laboratories are, in contrast to the Lund Nano Lab, distributed across Lund University.

NanoLund's interdisciplinary environment spans the departments of physics, chemistry, biology, medicine, and electrical engineering at Lund University. Researchers at these departments are involved in groundbreaking methodological developments in areas such as: electrical and optical nano-characterization, ultra-fast laser spectroscopy, scanning probe microscopy, transmission electron microscopy, synchrotron-based imaging, spectroscopy and scattering, nanosafety, computational quantum chemistry, biocompatible nanoelectrodes, and many-body and transport theory.

Members of NanoLund are also users of major cutting-edge characterization facilities at Large scale Research Infrastructures (LRIs), such as the MAX IV synchrotron in Lund. NanoLund members are also frequent users of neutron facilities worldwide and collaborate with the ESS (European Research Infrastructure Consortium). Some members are also actively involved in the development of beamlines at MAX IV and other LRIs.



Photo: Kennet Ruona

Education and Outreach

UNDERGRADUATE EDUCATION

The Engineering Nanoscience curriculum at LTH (Faculty of Engineering) is one of the few complete degree programmes in nanoscience in the world that starts at university entrance level and leads to a Master's degree. It was initiated in 2003 by NanoLund scientists.

The programme is a unique symbiosis of education and research. Teaching is driven by high-level research activities in the field, and research benefits from the highly qualified graduates leaving the programme. It provides a holistic perspective of nanoscience, in which specially designed courses in biology, biochemistry and medicine broaden the foundation provided by subjects such as physics, maths and chemistry.

The last few years NanoLund has strived for increased interactions also with other undergraduate education programmes. For example, since 2017 more than 120 undergraduate students from several different education programmes have signed up as NanoLund student members. A number of events have been organized for the student members during 2018, including a joint retreat with NanoLund PhD students and postdocs, talks and mingle with NanoLund alumni, scientific talks by young NanoLund scientists and an information event about Master's projects at NanoLund. In addition, five student members received NanoLund sponsorship to attend the nano-science student conference INASCON 2018 in Trondheim, Norway (these students will now organize INASCON 2020 in Lund).

OUTREACH

NanoLund members perform many outreach activities during the year. Some of the most important of these are popular science talks and outreach to the public, local schools and our undergraduate recruitment base.

In addition, and to reach a larger international audience, we regularly publish press releases that often results in publications by other newsmedia.

2018 ENGINEERING NANOSCIENCE STATS

- 43 Students started, of which
 - 18 women (42%)
 - 25 men (58%)
- 18.6 Grade point average needed for high school students ("meritvärde", scale is 1-20. Up to 2.5 can be added in certain circumstances for a maximum of 22.5)
- 31 Students graduated, of which 12 (39%) women and 19 (61%) men

2018 OUTREACH STATS

- 80 Online articles and press releases
- 19 Printed articles
- 3 Radio features
- 51 Popular science talks
- 30 of which for (junior to) high school students
 - 1 Commissioned education
 - 3 Contribution to specialist newspaper

Scientific publications

SCIENTIFIC PROGRESS

Peer reviewed journals is a crucial channel for communicating our scientific results. During 2018 publications for the environment overall averaged a journal impact factor (JIF) of 6.2.

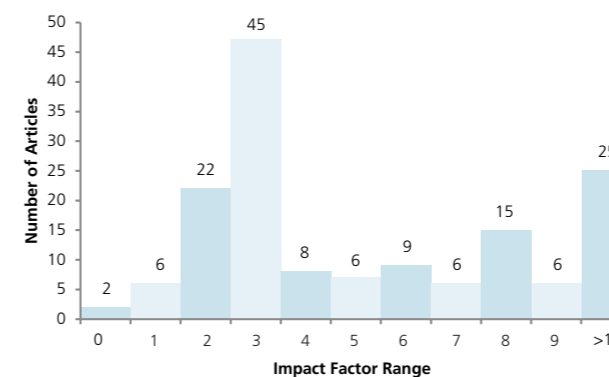
15% of publications relevant to nanoscience in 2018 were published in journals with a journal impact factor larger than 10. The bibliometrics of NanoLund in the field of nanowires has for many years been on par with the other world-leading research centers at UC Berkeley and Harvard.

The overall distribution of the journal impact factor remains similarly shaped compared to the last years. We consider the balance between high-impact factor papers with high visibility, and publications in archival journals with lower journal impact factor, a very good sign.

2018 METRICS

- 58 Members (principal investigators, lecturers and managers),
- 26 Affiliated members,
- 3 Emeritus members,
- 305 Publications in total, of these
- 160 specifically in nanoscience, and of these
- 25 with journal impact factor (JIF) > 10.
- 6 Nature, Nature family, Science & PNAS, and
- 14 Nano Letters.
- 6.2 Average impact factor (150 of 160 publications have a well-defined JIF)

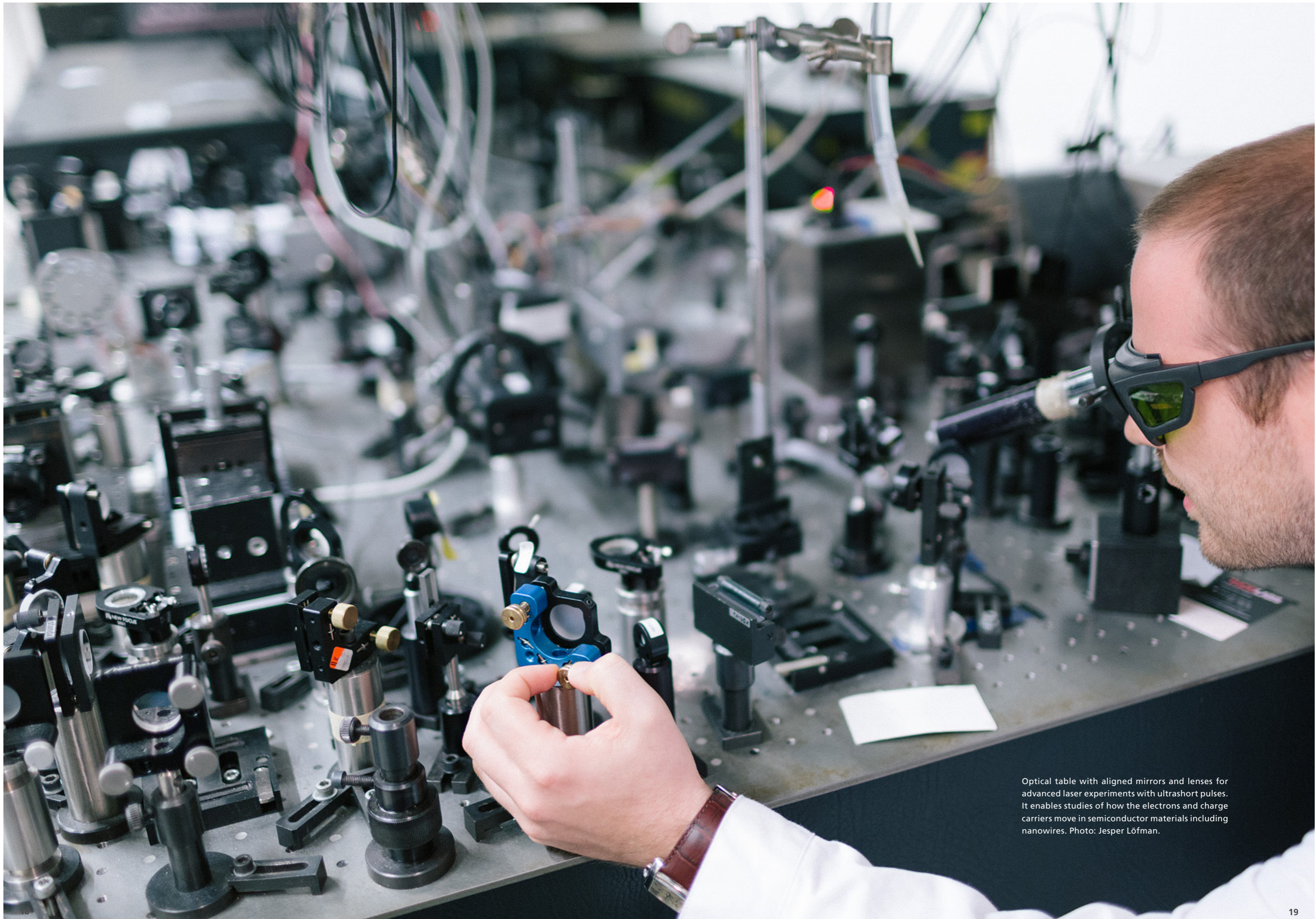
Nanoscience papers 2018, journal impact factor distribution



Nanoscience papers 2018, journal impact factor distribution (150 of 160 have well defined JIF).



Photo: Jesper Löfman



Optical table with aligned mirrors and lenses for advanced laser experiments with ultrashort pulses. It enables studies of how the electrons and charge carriers move in semiconductor materials including nanowires. Photo: Jesper Löfman.

2018 NanoLund Awards

NANOLUND AWARD FOR EXCELLENT TECHNICAL AND ADMINISTRATIVE SUPPORT

The excellent work done by technical and administrative support staff is of critical importance for NanoLund, and none of our work in teaching and research would be possible without it. This award recognizes outstanding achievements for technical and administrative personnel. This year's award was presented to:

- **Charlotte Solberg**, Finance Officer, Solid State Physics
- **Mariusz Graczyk**, Research Engineer, Solid State Physics

In addition, we presented a special Lifetime Achievement Award For Outstanding Support for excellent support and contributions during almost 40 years of employment. This was given to:

- **Sören Jeppesen**, Research Engineer, Solid State Physics

NANOLUND YOUNG TEACHER AWARD

Teaching is a very important part of our mission, and we are proud of the achievements by our young teachers. The awards recognize extraordinary commitment to teaching by junior scientists. In 2018 they were presented to:

- **Anette Löfstrand**, PhD student, Solid State Physics
- **Andrea Troian**, PhD student, Synchrotron Radiation Physics

NANOLUND JUNIOR SCIENTIST IDEAS AWARD

NanoLund seed projects give junior scientists (master students, PhD students and postdocs) the opportunity to propose and carry out new projects that are complementary to existing research directions in NanoLund. In the 2018 project call, 18 projects were received and evaluated by a group of senior scientists and PhD students, with an emphasis on originality, feasibility and potential impact. Five projects were selected for funding by a one-time sum of 100 000 SEK each for research expenses:

- **Martin Hjort**, Postdoc at Solid State Physics - Next generation gene therapies enabled by nanostraws
- **Axel Eriksson**, Postdoc at Ergonomics and Aerosol Physics - Single particle in-situ incandescence measurements on engineered nanoparticles
- **Elke Hebisch**, Postdoc at Solid State Physics - Live-cell STED microscopy of nanodiamonds with nitrogen vacancies as color centers, delivered to the cytoplasm by nanostraws and serving as long-term stable fluorescence probes
- **Tinna Pálmadóttir**, PhD student at Biochemistry and Structural Biology - Systematic study of the role of nanostructure surface charge and aspect ratio in protein fibrillation
- **Emil Johansson**, Master student at Division of Medical Microbiology - Teaching neural networks quantum mechanics



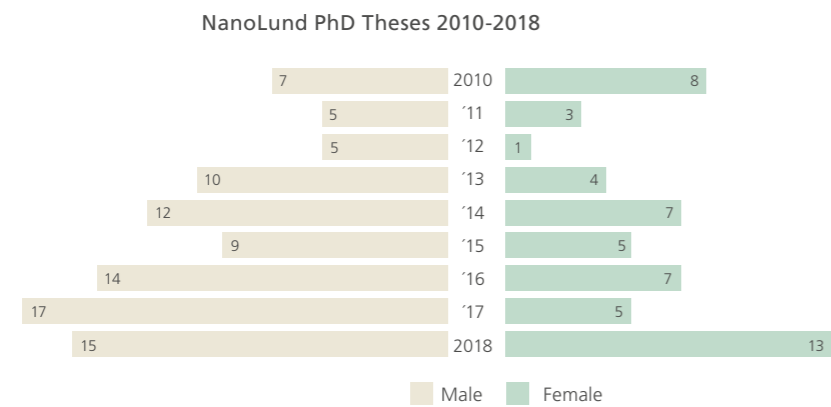
The 2018 NanoLund awards were presented and recognized at our Annual Meeting at AF-borgen in Lund on October 4th. Top: Mingle at the Annual Meeting. Left: Anette Löfstrand, one of the winners of the NanoLund Young teacher award. Below: Elke Hebisch, one of the winners of the Junior Scientist Ideas Award. Photo: Kennet Ruona

Graduate education

GRADUATE EDUCATION AT NANOLUND

NanoLund is Sweden's largest research environment for interdisciplinary nanoscience and nanotechnology, engaging more than 130 PhD students in sciences ranging from engineering to natural sciences and medicine. PhD students constitute roughly 1/3 of the staff engaged in NanoLund and are an important and integrated part of the research conducted. Below are the trends for completed doctoral theses from 2010 onwards, with gender specific statistics.

We are very proud of our 28 PhDs graduated in 2018 and wish them all a brilliant career!



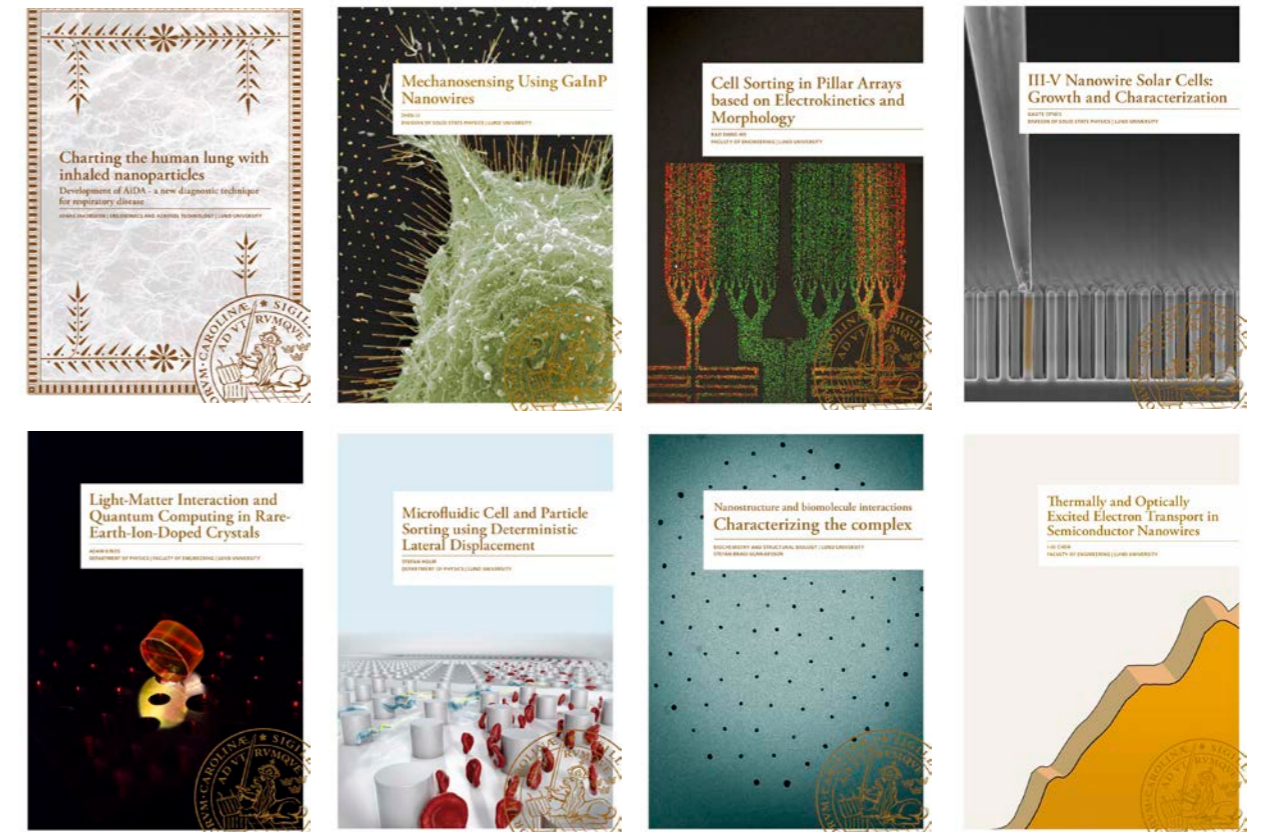
DOCTORAL THESES 2018

- Laura Abariute**
(Solid State Physics)
Engineered nanomaterials in vivo and in vitro models
- I-Ju Chen**
(Solid State Physics)
Thermally and Optically Excited Electron Transport in Semiconductor Nanowires
- Junsheng Chen**
(Chemical Physics)
Photophysics of Perovskite Nano- and Microcrystals
- Yang Chen**
(Solid State Physics)
III-V Nanowire Array Solar Cells: Optical and Electrical Modelling
- Vilgaile Dagyte**
(Solid State Physics)
Growth and optical properties of III-V semiconductor nanowires
- Stefan Gunnarsson**
(Biochemistry and Structural Biology)
Nanostructure and biomolecule interactions: Characterizing the complex
- Robert Hallberg**
(Solid State Physics)

- Aerosol Metal Nanoparticles and their Role in Particle-Assisted Growth of III-V Nanowires*
- Bao Ho**
(Solid State Physics)
Cell Sorting in Pillar Arrays based on Electrokinetics and Morphology
- Stefan Holm**
(Solid State Physics)
Microfluidic Cell and Particle Sorting using Deterministic Lateral Displacement
- Jonas Jakobsson**
(Ergonomics and Aerosol Technology)
Charting the human lung with inhaled nanoparticles
- Adam Kinos**
(Atomic Physics)
Light-Matter Interaction and Quantum Computing in Rare-Earth-Ion-Doped Crystals
- Hanna Landberg**
(Occupational and Environmental Medicine)
The Use of Exposure Models in Assessing Occupational Exposure to Chemicals

- Zhen Li**
(Solid State Physics)
Mechanosensing Using GalnP Nanowires
- Ali Nowzari**
(Solid State Physics)
Junction Engineering in Nanostructured Optoelectronic Devices
- Lisa Rullik**
(Synchrotron Radiation Research)
Industrial Alloys Studied by Surface Sensitive Techniques
- Regina Schmitt**
(Solid State Physics)
Feedback in Small Systems - A Stochastic Thermodynamic Perspective
- Rong Sun**
(Solid State Physics)
Understanding the Role of Seed Particle Material on III-As Nanowire Growth
- Artis Svilans**
(Solid State Physics)
Thermoelectric experiments on nanowire-based quantum dots
- Tanja Weiffert**
(Biochemistry and Structural Biology)
Unravelling protein stability and aggregation
- Damiano Verardo**
(Solid State Physics)
Lightguiding of Fluorescence in Nanowires
- Chunlin Yu**
(Solid State Physics)
Quantum Transport in Superconductor-Semiconductor Nanowire Hybrid Devices
- Xulu Zeng**
(Solid State Physics)
InP/GalnP Nanowires for Tandem Junction Solar Cells
- Klara Petersson**
(Biomedical Engineering)
Clinical applications of acoustophoresis in blood based diagnostics
- Gaute Otnes**
(Solid State Physics)
III-V Nanowire Solar Cells: Growth and Characterization

- Malin Nilsson**
(Solid State Physics)
Charge and Spin Transport in Parallel-Coupled Quantum Dots in Nanowires
- Qian Li**
(Atomic Physics)
Quantum memory development and new slow light applications in rare-earth-ion-doped crystals
- Luna Namazi**
(Solid State Physics)
From understanding to realizing novel III-Sb materials via nanowires
- Olof Hultin**
(Solid State Physics)
Nanostructures for Optoelectronics: Device Fabrication and Characterization





A great big
Thank you
to those who fund our research!

Funding

2018 INCOME IN MSEK

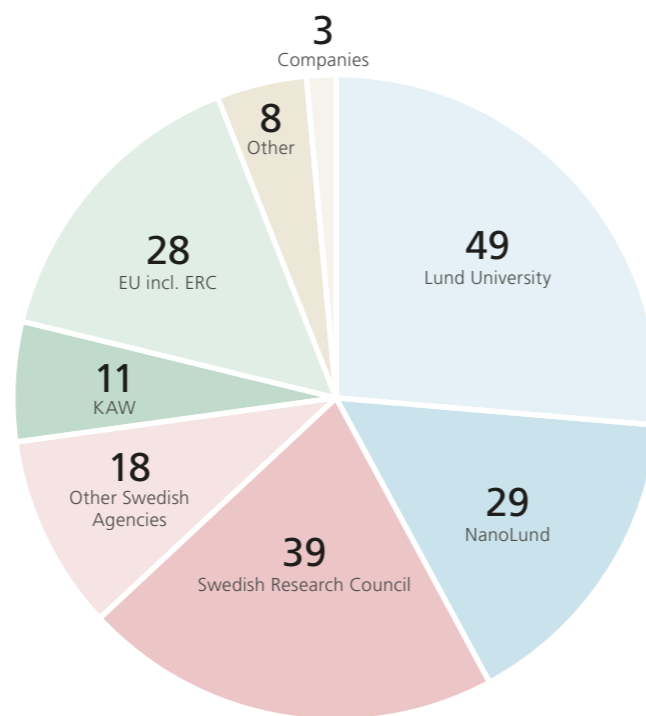
- 186** total income, of which
- 78** from the University, including
- 29** Strategic Research Area funding for NanoLund.
- 108** is external funding won in competitive calls. Breaking down the individual contributions there is about
- 39** from the Swedish Research Council (VR),
- 11** from the Knut and Alice Wallenberg foundation (KAW),
- 28** from EU funding including ERC,
- 18** from other Swedish funding agencies, (such as the Swedish Foundation for Strategic Research (SSF) and the Swedish Energy Agency),
- 8** from other grants,
- 3** from companies.

NANOLUND INCOME SOURCES FOR 2018

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

The total income is evaluated as the income of members, weighted with their degree of participation in NanoLund.

NanoLund Income Sources 2018 (MSEK)



LIST OF FUNDING BODIES

Alfred Österlunds Stiftelse
AFA Insurance
Alzheimerfonden
Barncancerfonden - The Swedish Childhood Cancer Fund
Carl Tesdorpf's stiftelse
Carl Tryggers stiftelse för vetenskaplig forskning
The Crafoord Foundation
European Commission's Research and Innovation Activities: European Research Council (ERC), Marie Skłodowska-Curie Actions, Horizon 2020 and FP7
Formas
Forte Swedish Research Council for Health, Working Life and Welfare
KMA - Stiftelsen Kronprinsessan
Margaretas Arbetsnämnd för synskadade
The Knut and Alice Wallenberg Foundation
LMK -stiftelsen Foundation for Interdisciplinary Scientific Research
Mistra
The National Research Center for the Working Environment (NFA) in Denmark

Olle Engkvists stiftelse
Public Health Agency of Sweden
Region Skåne
The Royal Physiographic Society of Lund
Segeffalkstiftelsen
Sida - Swedish International Development Cooperation Agency
Sten K Johnson Foundation
STINT - The Swedish Foundation for International cooperation in Research and Higher Education
The Swedish Energy Agency
Swedish Environmental Protection Agency
The Swedish Foundation for Strategic Research
The Swedish Heart-Lung Foundation
The Swedish Research Council
Swedish Work Environment Authority
The Thorsten and Elsa Segerfalk Foundation
Vinnova
Volkswagenstiftung

EUROPEAN FUNDING

The NanoLund environment continues to be active on a European level, applying for individual grants and collaboration projects.

In 2018 members of NanoLund:

- Held 6 active ERC grants
- 6 active ERC projects
- Participated in 13 EU projects
- Coordinated 4 EU projects & 1 Marie Skłodowska-Curie individual fellowship



Photo: Kennet Ruona



NanoLund External Advisory Board

From the left: Henning Riechert, Chris Palmstrøm, Friedrich Simmel, Stephen Goodnick, Ulla Vogel, Chi-Chang Kao (missing: Evelyn Hu).
Photo: Kennet Ruona

Organisation

HOW NANOLUND IS SET UP

NanoLund is a truly crossdisciplinary research center, engaging in total more than 300 scientists, teachers and staff from more than 20 divisions over three faculties - Engineering (LTH), Science and Medicine.

The NanoLund Management is led by an Executive Group with responsibility for day-to-day management and long-term planning. NanoLund is organized into seven research areas:

- Materials Science
- Quantum Physics
- Nanoelectronics & Nanophotonics
- Nanoenergy
- Nanobiology & Neuronanoscience
- Nanosafety
- Exploratory Nanotechnology

The scientific work is enabled and supported by three key resource areas, namely: Lund Nano Lab (LNL), Lund Nano Characterisation Labs (LNCL) and education.

Each research- and resource area has a coordinator and a co-coordinator, who have important roles in prioritizing activities and developing strategic aims.

NanoLund is headed by a Board, which defines strategy and makes formal decisions.

The center is advised by an international Scientific Advisory Board and by an External Advisory Council from society, academia and industry.

During 2016-2020 NanoLund works with the following long-term strategic aims:

Highly controlled nanostructures

To realize, model and characterize nanostructures, devices and systems with atom-level control.

Fundamental science for future devices

To discover fundamental physics, materials science and paradigms that may lead to future energy and ICT devices with enhanced performance.

Tools for single-cell biomedicine

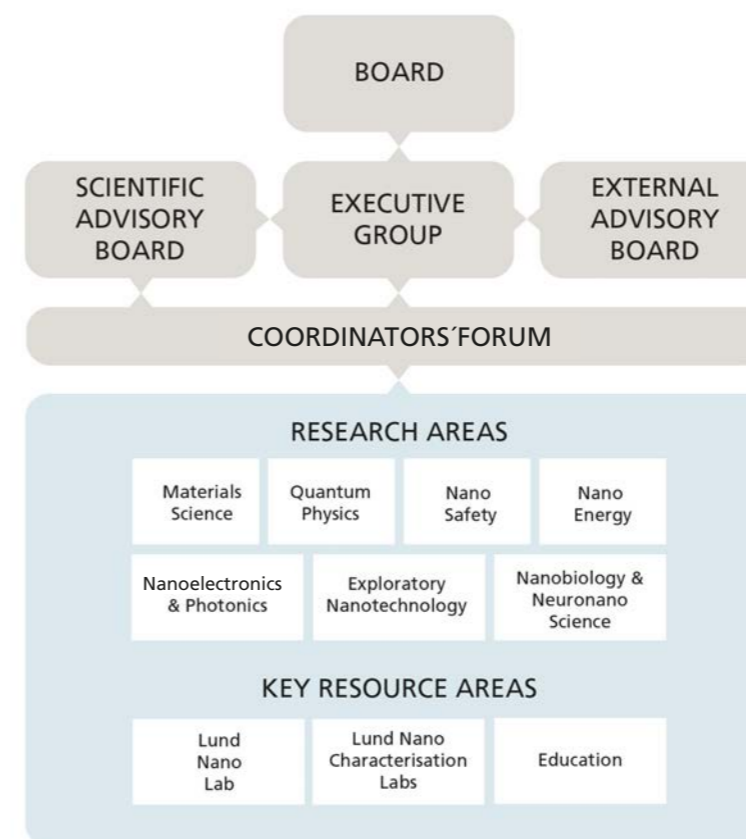
To develop sensors, probes, stimulators and single-molecule methods for single- and few-cell biomedicine.

A Great Place to do Nanoscience

To be an internationally highly visible nanoscience center that offers exceptional scientific opportunities, training and career development.

Nanomaterials industry

To establish an ecosystem that integrates education, research, R&D and pilot production to take ideas from research to the marketplace.



2018 NanoLund Board Members:

- Viktor Öwall (Chair), Dean, LTH*
- Kimberly Dick, LTH*
- Peter Honeth, former State Secretary*
- Victor Lantz, Student representative*
- Erik Lind, LTH*
- Heiner Linke, Director, NanoLund*
- Sara Linse, Science faculty*
- Camilla Modéer, IVA*
- Karolina Mothander, Student representative*
- Lars Palm, Tetra Pak*
- Kristian Pietras, Medical faculty*

2018 Executive Group:

- Heiner Linke (Director)*
- Lars Samuelson (Vice-Director)*
- Anneli Löfgren (Co-Director)*
- Anders Mikkelsen (Co-Director)*

2018 External Advisory Board:

- Evelyn Hu, Harvard University*
- Stephen Goodnick, Arizona State University*
- Chi-Chang Kao, SLAC/Stanford University*
- Chris Palmstrøm, UC Santa Barbara*
- Henning Riechert, Paul Drude, Berlin*
- Friedrich Simmel, TU München*
- Ulla Vogel, NFA, Denmark*

2018 External Advisory Council:

- Camilla Modéer (Chair), IVA*
- Ola Asplund, IF Metall*
- Anna Stenstam, CR Competence AB*
- Peter Honeth, former State Secretary*
- Lars Börjesson, Chalmers University*
- Per Krokståde, IKEA of Sweden AB*

Coordinators' Forum consists of:

- Executive group,
- Chair of the Board,
- Coordinators and co-coordinators of the subareas and resource areas,
- Student representatives to the Board



INFO

This is the 2018 Annual Report for the NanoLund research environment at Lund University presenting scientific, educational, outreach and public impact highlights, progress, data and trends for and up to 2018.

This report is based on material and data compiled and edited by the staff of NanoLund, in particular:

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Communications and Coordination

Anna-Karin Alm

External Relations Officer

Anneli Löfgren

Administrative Director

Heiner Linke

Director

