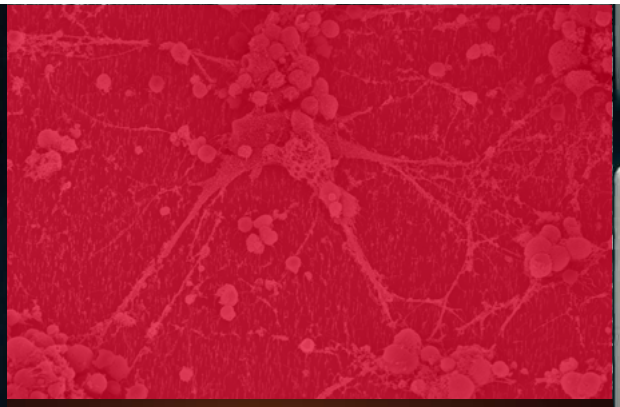
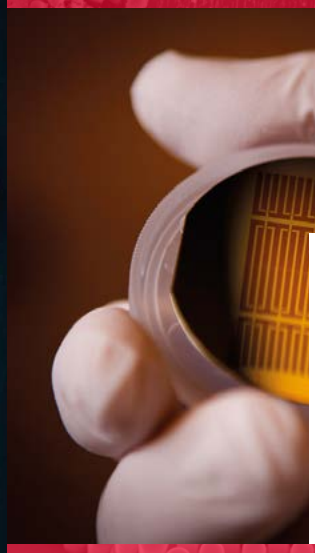
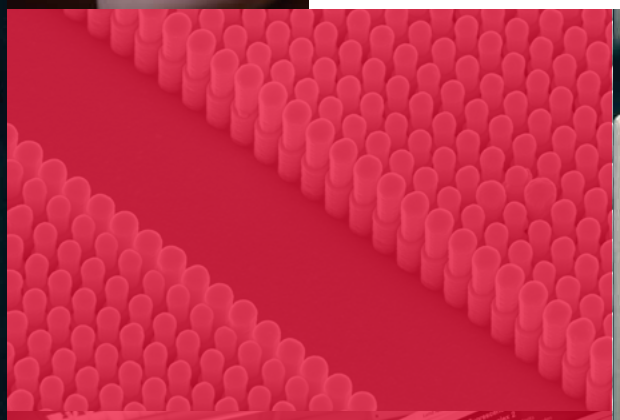


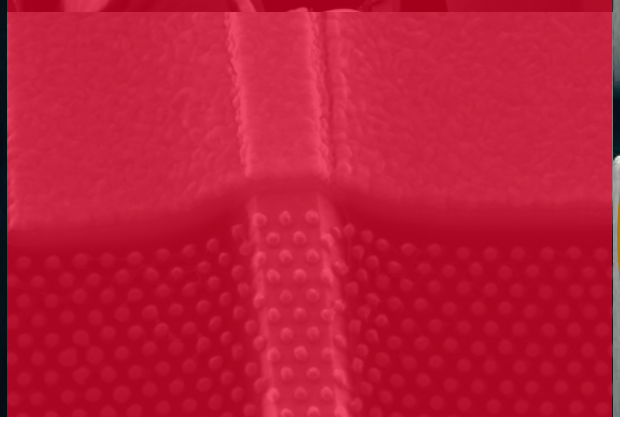


LUND UNIVERSITY

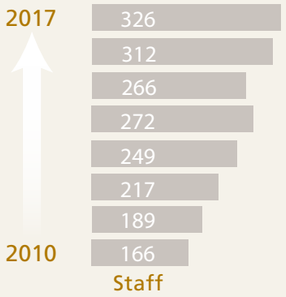
NANOLUND

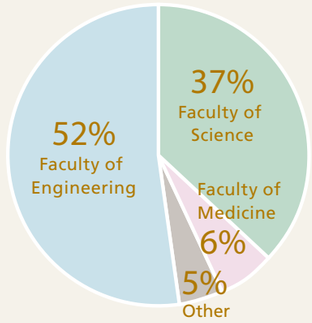
ANNUAL REPORT FOR 2017





2017 IN BRIEF





In 2017, NanoLund:
Included 8 ERC Awardees
Participated in 14 EU projects
Coordinated 5 EU projects & 1 Marie Curie European individual fellowships

Current numbers

21	Contributing LU divisions
Faculty Members	63
32%	Women
PhD students	132
194 MSEK	Funding 61% external
Average impact factor	7.2

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

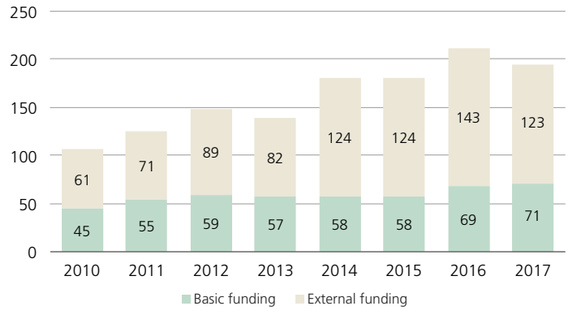
2007 Inauguration of Lund Nano Lab

2010 Strategic Research Area funded by the Swedish Government

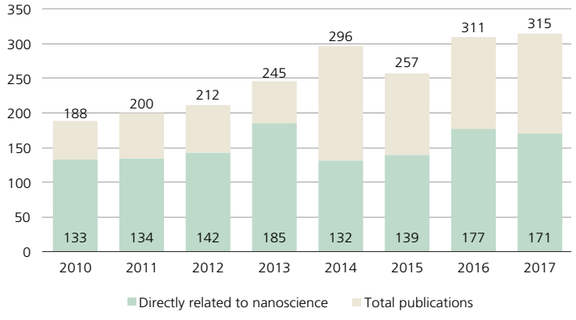
2015 nmC becomes NanoLund, the Center for Nanoscience at Lund University

TRENDS

Funding over time (MSEK)



Total number of publications



FOREWORD


Image by Magnus Bergström for The Knut and Alice Wallenberg Foundation

At the Forefront of Nanoscience

During 2017 we took important steps forward in a number of processes that will shape the way NanoLund will develop in the next 10 years.

In one such process we developed, during a series of inspiring workshops and discussions, a set of joint core values (see page 17) describing the culture we aspire to for NanoLund. These guiding principles offer help in big and small decisions, and provide a common ground for our large and diverse environment.

We also continue to work hard for the opportunity to establish future NanoLund activities in Science Village in close synergy with MAX IV and ESS. Towards this aim, we are moving forward in planning the new Lund Nano Lab, including a targeted, professional fundraising effort, we actively help in developing Lund University's strategy for Science Village, and we help develop the pilot production facility ProNano. Our vision is that, in five to ten years, NanoLund will be at the center of what will be Europe's place to be for research on highly controlled semiconductor nanostructures.

During the year, NanoLund has been moving forward also in measurable units, such as an increase of the average journal impact factor (JIF) of the journals we publish in, to now above 7 (see page 6). I am particularly glad to see that we balance the high-impact papers by also publishing a large number of in-depth works in archival journals with long-lasting value. This balance of depth and visibility is a hallmark of a truly pioneering environment.

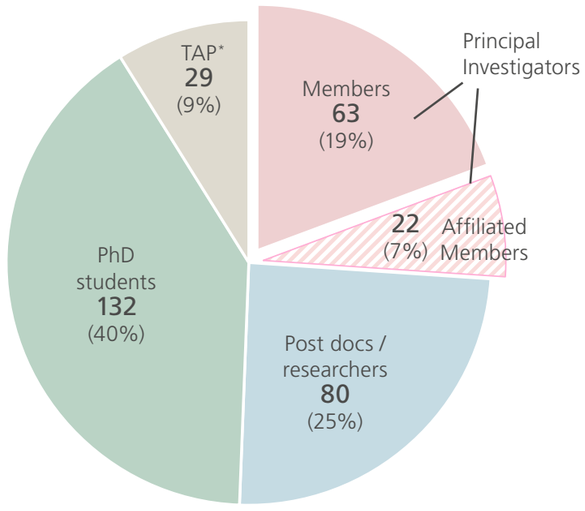
Thank you to all our technical and administrative staff, teachers and scientists for all your enthusiastic work, and to our collaborators, funders, university and regional leaders as well as industry representatives for all your support. None of what we do would be possible without you.

HEINER LINKE
NANOLUND DIRECTOR

CONTENTS

PEOPLE & SELECTED NEWS

People per personnel category 2017



* TAP = Technical and Administrative Personnel

PERSONNEL & MEMBERSHIP

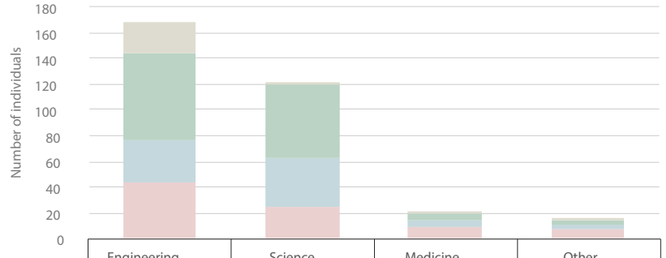
The number of individuals involved in NanoLund is roughly the same in total for all categories in 2017 compared to 2016, except for a slight increase in the number of PhD students (+11 people) compared to the previous year. The average annual level of engagement in NanoLund overall is about 60%, which corresponds to 201 full-time equivalents. Looking at the long-term trends, we note that the number of PIs has been approximately constant for the past eight years, while all other categories have been growing. This indicates a healthy growth of the individual research groups and infrastructures.

Gender Balance 2017

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

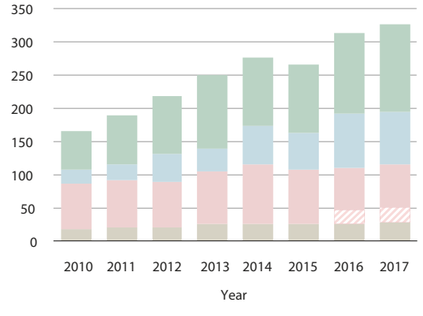
PIs:	24% women	76% men
Postdocs:	28% women	72% men
PhD stud.:	42% women	58% men

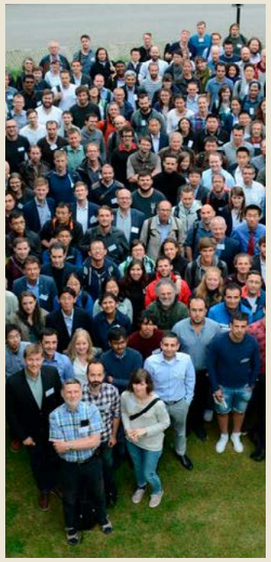
NanoLund people by faculty, 2017



	Engineering	Science	Medicine	Other
TAP*	24	3	1	1
PhD students	67	56	6	3
Post docs / researchers	33	38	5	4
Principal Investigators	44	25	9	7

Personnel trends 2010-2017





NANOWIRE WEEK 2017

2017-05-05 - 2017-06-02

The annual international Nanowire Week was held in Lund this year with Kimberly Dick Thelander as Chair. Nanowire Week is the merger of two well-established and highly successful annual workshops: NANOWIRES and the Nanowire Growth Workshop. Nanowire Week covered all topics of nanowire-related research, from fabrication and fundamental properties to applications. This year saw over 200 participants gathering from all over the world to discuss nanowire science in an open and dynamic environment.
Open questions, unexpected findings, and unconventional ideas are always encouraged at the Nanowire Week.

RESEARCH ENVIRONMENT FUNDING

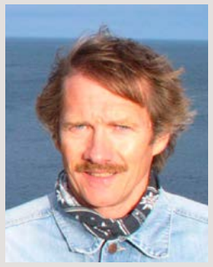
2017-02-23

Jens Schouenborg was awarded 24MSEK over six years in a VR reseacrh centre grant for his project (swedish title): ”Utveckling av implanterbar och vävnadsvänlig opto-elektronisk teknik för att monitorera och kommunicera med den medvetna hjärnans nervceller”.

MOBILE PHONE MICRODIAGNOSTICS

2017-04-03

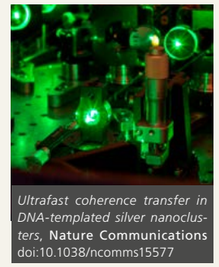
The Swedish Research Council has decided to support a project lead by Jonas Tegenfeldt on diagnosing disease such as sleeping sickness and malaria in remote locations in Africa with the help of a nanotechnology based device coupled to a mobile phone camera. The method will enable quick and precise diagnosis with minuscule samples.



TÖNU PULLERITS IN THE ACADEMY

2017-05-16

Tönu Pullerits was elected foreign member of the Academy’s Class for chemistry at the General Meeting of the Royal Swedish Academy of Sciences.



Ultrafast coherence transfer in DNA-templated silver nanoclusters, **Nature Communications** doi:10.1038/ncomms15577

EFFICIENT BIOSENSORS WITH SILVER ATOM NANOCLUSTERS

2017-07-07

Donatas Zigmantas and Erling Thyrhaug from NanoLund, with researchers from the University of Copenhagen, studied nanoclusters consisting of 20 silver atoms. For the first time, the researchers identified an ultrafast energy flow linked to the structural changes that occur when light excites these nanoclusters.

$21 MILLION FOR SOLVOLTAICS

2017-08-15

NanoLund spin-out Sol Voltaics secured 21 million US dollars in a funding round over the summer. The new financing will be used to accelerate commercialization of its highly anticipated solar efficiency boosting technology, SolFilm™ which promises to increase conventional solar panel efficiencies by up to 50%.

GOOGLE INVESTS IN GLO’S MICROLED

2017-08-25

Rapidus reports that Google Inc has invested 120 MSEK in Glo, a spin-out from NanoLund. Glo is developing RGB direct-emitting display panels with better contrast and lower power consumption than LCD screens while yielding higher overall brightness than OLED. In total Glo has attracted about 1200 MSEK in investments since the start in 2008.

EUROPEAN RESEARCH COUNCIL STARTING GRANT TO PETER JÖNSSON

2017-09-12

Peter Jönsson has been granted an ERC Starting Grant of 1.5 M Euro for 5 years. The project named SELFOR explores how an immune response starts at a molecular level, and how our immune system can separate between “self” and “foreign” molecules.

KNUT AND ALICE WALLENBERG GRANT TO KIMBERLY DICK THELANDER

2016-10-03

NanoLund scientists led by Kimberly have been awarded 34,2 MSEK over five years for the project ”Controlled atomic scale 3D ordering for exotic electronic phases”. The highly competitive grants give the researchers the opportunity to try out new and bold ideas over an extended period.

NORBLAD-EKSTRAND MEDAL TO TOMMY NYLANDER

2017-10-09

Tommy Nylander was awarded the Norblad-Ekstrand medal by the Swedish Chemical Society. In connection with this he gave a talk entitled ”Reflections on the biointerface: Structure, interactions and processes” at the Department of Chemistry.

THE UNBELIEVABLE SPEED OF ELECTRON EMISSION FROM AN ATOM

2017-11-28

Anne L’Huillier has been involved in a study clocking how long atomic emission of electrons takes. The result: *20 billionths of a billionth of a second*. The stopwatch consists of extremely short laser pulses. Hopefully, the results will provide new insights in some of the most fundamental processes in nature.

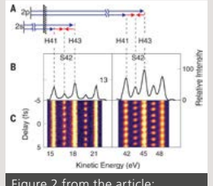
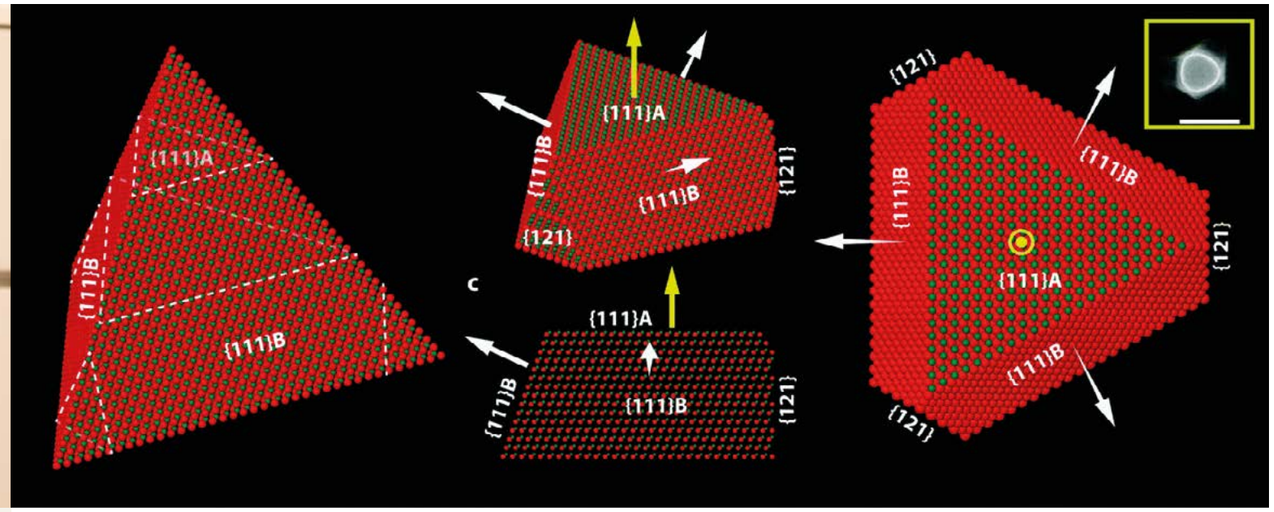


Figure 2 from the article: *Photoionization in the time and frequency domain*, **Science,** DOI: 10.1126/science.aao7043

RESEARCH



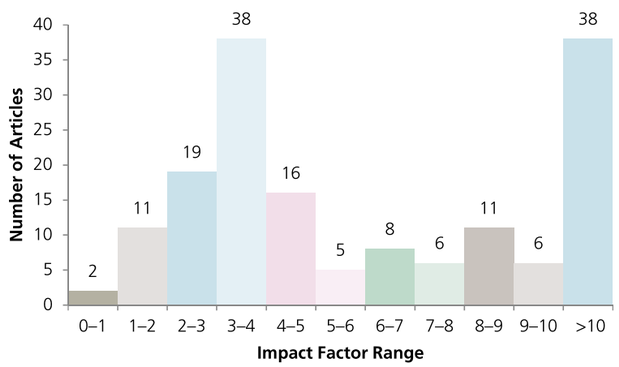
SCIENTIFIC PROGRESS

2017 has seen a significant improvement in the quality of publications with a relatively high average Journal Impact Factor (JIF) of 7.2 of the journals we publish in for the environment overall.

22% of publications relevant to nanoscience in 2017 were published in journals with a journal impact factor larger than 10. This is a great improvement over last year already high value (14%), but we reserve judgement on any single year until we are ready to observe trends over a longer term. The bibliometrics of NanoLund in the field of nanowires has for many years been on a par with the other world-leading research centres at UC Berkeley and Harvard.

The overall distribution of the journal impact factor remains similarly shaped compared to last year, with the significant changes being a shift in numbers towards higher impact factor journals. We consider the balance between high-impact factor papers with high visibility, and publications in archival journals with lower JIF, a very good sign.

Nanoscience papers 2017, Journal Impact Factor distribution
(160 of 171 have well defined JIF).



2017 METRICS

63 Members (Principal Investigators, Lecturers and Managers),

21 Affiliated Members,

315 Publications in total, *of these*

171 specifically in Nano-science, *and of these*

38 with journal impact factor (JIF) > 10.

11 Nature, Nature family, Science & PNAS, and

19 Nano Letters.

7.2 Average impact factor (160 of 171 publications have a well-defined JIF)

21 Conference Papers.

PUBLICATION HIGHLIGHTS OF THE YEAR

NATURE

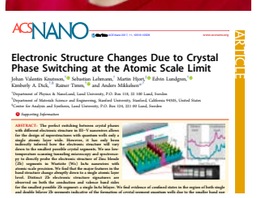
NanoLund PI: *Kenneth Wärnmark*
doi:10.1038/nature21430

A LOW-SPIN FE(III) COMPLEX WITH 100-PS LIGAND-TO-METAL CHARGE TRANSFER PHOTOLUMINESCENCE

Transition-metal complexes are used as photosensitizers, in light-emitting diodes, for biosensing and in photocatalysis. A key feature in these applications is excitation from the ground state to a charge-transfer state; the long charge-transfer-state lifetimes typical for complexes of ruthenium and other precious metals are often essential to ensure high performance. There is much interest in replacing these scarce elements with Earth-abundant metals. Here we present an iron complex and show that the superior sigma-donor and pi-acceptor electron properties of the ligand stabilize the excited state sufficiently to realize a long charge-transfer lifetime of 100 picoseconds (ps) and room-temperature photoluminescence. Intriguingly, there is an absence of intersystem crossing, which often gives rise to large excited-state energy losses in transition-metal complexes. These findings suggest that appropriate design strategies can deliver new iron-based materials for use as light emitters and photosensitizers. (Abridged abstract.)

ACS NANO

NanoLund PI: Anders Mikkelsen
doi:10.1021/acsnano.7b05873



ELECTRONIC STRUCTURE CHANGES DUE TO CRYSTAL PHASE SWITCHING AT THE ATOMIC SCALE LIMIT

The perfect switching between crystal phases with different electronic structure in III–V nanowires allows for the design of superstructures with quantum wells only a single atomic layer wide. However, it has only been indirectly inferred how the electronic structure will vary down to the smallest possible crystal segments. We use low-temperature scanning tunneling microscopy and spectroscopy to directly probe the electronic structure of Zinc blende (Zb) segments in Wurtzite (Wz) InAs nanowires with atomic-scale precision. We find that the major features in the band structure change abruptly down to a single atomic layer level. Distinct Zb electronic structure signatures are observed on both the conduction and valence band sides for the smallest possible Zb segment: a single InAs bilayer. Our findings directly demonstrate the feasibility of crystal phase switching for the ultimate limit of atomistic band structure engineering of quantum confined structures. Further, it indicates that band gap values obtained for the bulk are reasonable to use even for the smallest crystal segments. However, we also find that the suppression of surface and interface states could be necessary in the use of this effect for engineering of future electronic devices. (Abridged abstract.)

2017 SELECTED HIGHLIGHTS PER RESEARCH AREA

MATERIALS SCIENCE

We showed through atomically resolved STM that Sb preferentially incorporates into the surface layer of Zb rather than Wz segments (by a factor of 4). DFT calculations show that this is related to differences in the energy barrier for the Sb-for-As exchange reaction.

Subareas:
- Controlled fabrication of advanced nanostructures
- Characterisation and properties
- Developing new processes and applications

Coordinator & Co-coordinator:
Reine Wallenberg
Maria Messing

Nano Lett. 17, 6, 3634-3640 (2017)

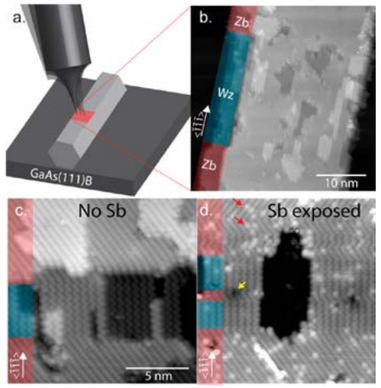


Fig. 2 from *Crystal Structure Induced Preferential Surface Alloying of Sb on Wurtzite/Zinc Blende GaAs Nanowires*

QUANTUM PHYSICS

We proposed a set up for minimal witness of entanglement between two flying electron qubits. Here only two current cross correlation measurements are needed, for any settings. All entangled pure states, but not all mixed ones, can be detected in this setup with exception of maximally entangled states (Bell states), which require three measurements.

Subareas:
- Transport Physics
- Quantum Information
- Optical Physics

Coordinator & Co-coordinator:
Stephanie Reimann
Niklas Sköld (to Sept 2017), Ville Maisi (from Sept 2017)

Phys. Rev. Lett. 118, 036804 (2017)

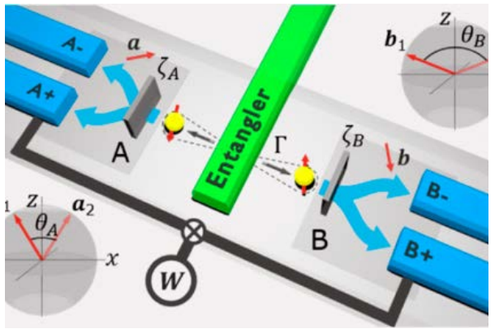


Fig. 1 from *Minimal Entanglement Witness from Electrical Current Correlations*. Schematic of the generic entangler-detector setup, consisting of an entangler and two detector systems A and B. The entangler generates split pairs of entangled electrons, in either spin or orbital degrees of freedom.

NANOELECTRONICS AND PHOTONICS

People in this reserach area offered a path to continue Moore's law by addresing the major challenge, of integrating III–V's on Si using vapor–liquid–solid grown vertical nanowires. They demonstrated vertical III–V MOSFETs achieving off-current below 1 nA/μm while still maintaining on-performance comparable to InAs MOSFETs. This approach opens a path to address not only high-performance applications but also IoT applications that require low off-state current levels.

Subareas:
- Nanoelectronics
- Spin based devices
- Nanophotonics

Coordinator & Co-coordinator:
Mats-Erik Pistol
Erik Lind

Nano Lett. 17, 10, 6006-6010 (2017)

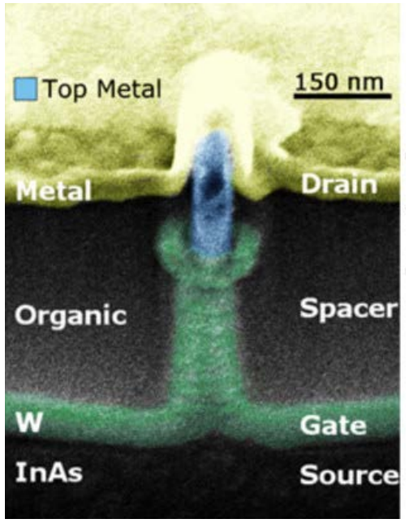


Fig. 2(b): finalized device, from *Vertical InAs/InGaAs Heterostructure Metal–Oxide–Semiconductor Field-Effect Transistors on Si*

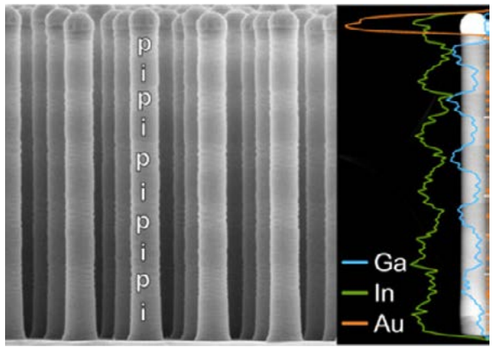
NANOENERGY

We demonstrated that semiconductor nanowires are versatile building blocks for optoelectronic devices by enabling the growth of ternary alloy nanowires in which the bandgap is tunable over a large energy range, desirable for optoelectronic devices. We also demonstrated degenerate p-doping levels in $In_xGa_{1-x}P$ nanowires by making an Esaki tunnel diode.

Subareas:
- Nanowire photovoltaics
- Light Emitting Diodes
- Nanothermodynamics

Coordinator & Co-coordinator:
Magnus Borgström
Peter Samuelson

Nano Lett. 17, 2, 702-707 (2017)



Abstract figure from *$In_xGa_{1-x}P$ Nanowire Growth Dynamics Strongly Affected by Doping Using Diethylzinc*, showing that the growth dynamics are strongly affected when diethylzinc is used as a dopant precursor.

NANOSAFETY

We demonstrated that plastic nanoparticles reduce the survival of aquatic zooplankton and penetrate the blood-to-brain barrier in fish and cause behavioural disorders. For the first time, we uncovered direct interactions between plastic nanoparticles and brain tissue. Our findings demonstrate that plastic nanoparticles disrupt the function of ecosystems.

Strategic aims:
- Building a strong nanosafety community
- Supply of expertise and communication in nanosafety
- Support of knowledge building about occupational and environmental exposure and biological effects

Coordinator & Co-coordinator:
Tommy Cedervall
Anders Gudmundsson

Nature Scientific Reports 7, 11452 (2017)

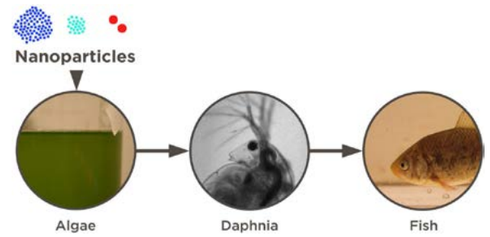


Fig. 2, Food chain from *Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain*. The image shows the food chain from algae-zooplankton-fish, nanoparticles (53 nm mass (dark blue), 53 nm surface area (light blue) and 180 nm (red)). The article in question generated a lot of visibility internationally due to several news outlets picking up the story

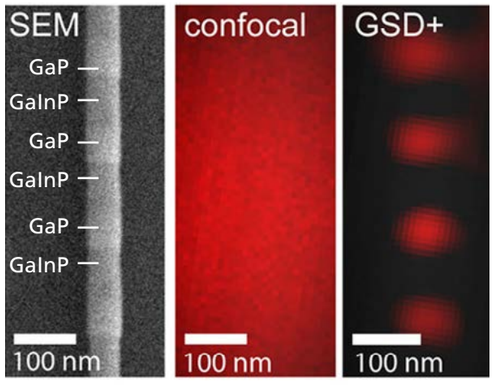
NEURONANOSCIENCE AND NANOBIOLOGY

We reported that ground state depletion (GSD) nanoscopy resolves heterostructured semiconductor nanowires formed by alternating GaP/GaInP segments ("barcodes") at a 5-fold resolution enhancement over confocal imaging. The far-red excitation wavelength make GSD nanoscopy attractive for imaging semiconductor structures in biological applications.

Subareas:
- Nanowires for interaction with neurons
- Fundamental cell-nanowire interactions
- Single-molecule and single-cell biophysics

Coordinator & Co-coordinator:
Jonas Tegenfeldt
Jens Schouenborg

Nano. Lett. 17, 4, 2652-2659 (2017)



Extract of abstract figure in *Ground State Depletion Nanoscopy Resolves Semiconductor Nanowire Barcode Segments at Room Temperature.*

NANOLUND VISIBILITY WORLDWIDE

NanoLund members work hard to disseminate scientific results. In 2017 we have collectively been to 25 different countries presenting our scientific work in nanoscience.
A few selected talks are highlighted here.

2016 SCIENTIFIC TALKS

78 Invited Talks

19 Keynote & Plenary

INVITED TALK
EP2DS-22/MSS-18
in State College, USA

Artis Svilans (PhD student)

Experimental Demonstration of a High Efficiency Particle-Exchange Heat Engine Using a Semiconductor Quantum Dot

KEYNOTE
3rd Annual Inhalation & Respiratory Drug Delivery Congress
London, UK

Jakob Löndahl

Deposition of Nanoparticles in the Respiratory Tract

INVITED TALK
8th int. symposium on nanotech, occupational and environmental health in Elsinore, Denmark

Neserin Ali (PhD student)

Proteomic analysis of nasal lavage samples collected from welders experimentally exposed to welding fume nanoparticles

KEYNOTE
Oorgandagarna
in Nynäshamn, Sweden

Reine Wallenberg

Real-time TEM viewing of growth of semiconductor nanostructures

KEYNOTE
28th int. conf. on Low Temp. Physics in Gothenburg, Sweden

Ville Maisi

Probing degeneracy, spin configuration and hybridization of GaAs based quantum dotvv

INVITED TALK
BIT's 7th Annual World Congress of Nano Science and Technology 2017 in Fukuoka, Japan

Rainer Timm

Atomic-scale Surface and Interface Characterization of Semiconductor Nanowires during Device Operation

INVITED TALK
ACS Spring Meeting
in San Fransisco, USA

Tommy Nylander

Lipid non-lamellar phases at the solid/liquid interface - structure and dynamics

INVITED TALK
2017 Gordon Research Conference on Crystal Growth & Assembly in Biddeford, USA

Magnus Borgström

Enabling nanowire photovoltaics

KEYNOTE
Annual DPG Meeting 2017
in Münster, Germany

Eva Unger

Roadmap and roadblocks for multi-junction device technology based on metal halide perovskites

KEYNOTE
48th IEEE-SISC 2017,
in San Diego, USA

Lars Samuelson

Semiconductor nanowires and their interface properties enabling photovoltaics and lighting applications

KEYNOTE
SMEE in Hong Kong, China

Hongqi Xu

Semiconductor Nanowires: Band Structures and Potential Applications in Nanoelectronics, Optoelectronics and Quantum Technologies

PLENARY
PQE-2017 in Snowbird, USA

Stefan Kröll

Quantum information, quantum optics & laser frequency stabilization based on rare earth crystals

INVITED TALK
SPIE 2017
in San Fransisco, USA

Håkan Pettersson

Physics and Technology of Nanowire Infrared Photodetectors

INVITED TALK
EMRS Spring Meeting
in Strasbourg, France

Jesper Wallentin

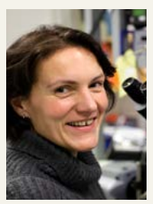
Nanofocused X-ray beam induced current in single nanowire devices

PLENARY
Spectroscopy of Emerging Functional Materials
in Mandi, India

Tönu Pullerits

New solar materials and spectroscopymaterials

INVITED TALK
63rd International Electron Devices Meetings
in San Fransisco, Portugal



Christelle Prinz

Interactions between nanowires and living cells

INVITED TALK
MNE 2017 - Conference on Micro and Nanoengineering
in Braga, Portugal

Elisabeth Nilsson

Communication Science in Society

INVITED TALK
AMN8 in Queenstown, New Zealand

Heiner Linke

Thermoelectric and photothermoelectric energy conversion in nanowires

LEGEND

- Invited Talks (size proportional to number)
- Keynote & Plenary Talks

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 m^2 ISO 5-7 cleanrooms for cutting edge nanofabrication

2017 LNL STATISTICS

52 090	Hours booked	25	External users
139	Active users	84	Total tools, of these
114	University users	64	tools are bookable

RESEARCH HIGHLIGHT

Researchers working at LNL developed a microfluidic sorting device that fractionates a mixed bacterial population into subpopulations based on the shape of the bacteria. In this way, they have successfully demonstrated the purification of single cocci and diplococci as well as the enrichment of chains from a standard sample of cultured bacteria. The devices are made using soft lithography based on a mold defined using UV-lithography.

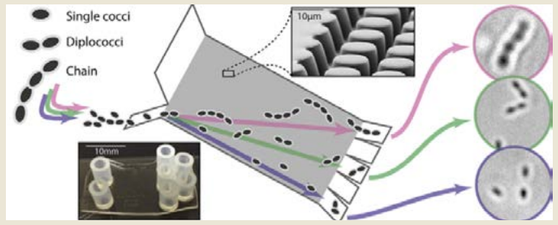


Figure: Graphic summary of the bacterial shape sorting project. A mixed population of the bacteria enter the device at the left-hand side in the small entrance channel. The trajectories of the bacteria now depend on the state of the bacteria. Single cocci move straight. Chains are entirely deflected. Diplococci move in intermediate trajectories.

Beech, J.P., B.D. Ho, G. Garriss, V. Oliveira, B. Henriques-Normark, and J.O. Tegenfeldt, Separation of pathogenic bacteria by chain length. Analytica Chimica Acta, 2018. 1000: p. 223-231.

LNL is a member of: myfab

Maria Huffman, Lab Director, LNL

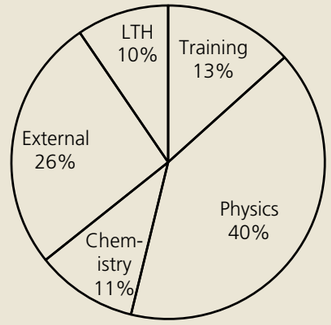
Ivan Maximov, Coordinator, LNL

Reine Wallenberg, Director, nCHREM

nCHREM - NATIONAL CENTER FOR HIGH-RESOLUTION MICROSCOPY

State-of-the-Art tools for Electron Microscopy

The facility is situated within the Chemical Center at Lund University. We offer expertise in imaging, element analysis, and sample preparation for a wide variety of sample types. The nCHREM also provides equipment for element analyses, 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 usage stats below are the division of active time on the available instruments.

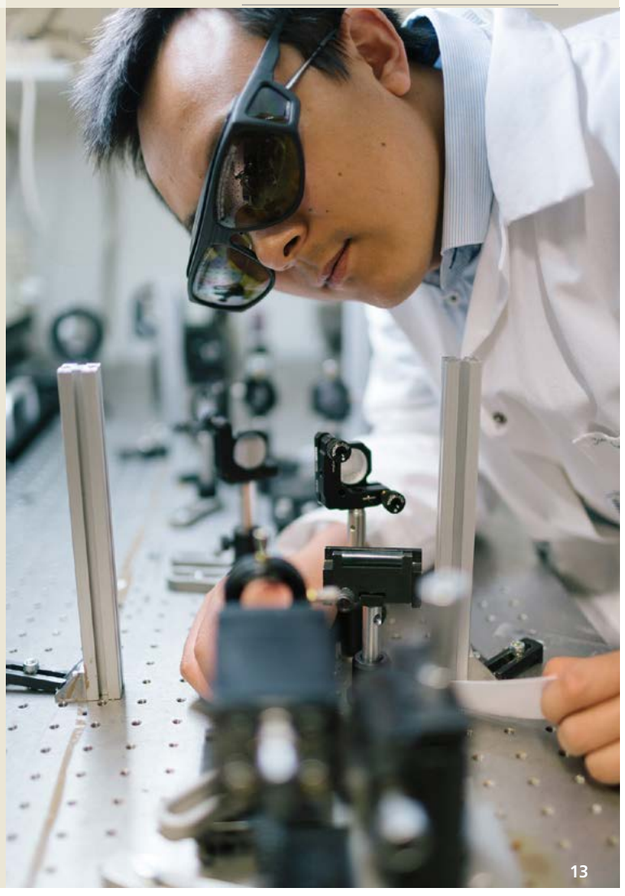


LUND NANO CHARACTERISATION LABS

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 from 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 nanocharacterization, 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 ERIC. Some members are also actively involved in the development of beamlines at MAX IV and other LRIs



INFRA NEWS

ENVIRONMENTAL TRANSMISSION ELECTRON MICROSCOPE AT NCHREM READY FOR ACTION

The unique ETEM microscope developed by Hitachi is producing its first results. At a cost of 35 MSEK and financed by the Knut and Alice Wallenberg foundation, it has a nominal resolution of 83 picometers - fine enough to resolve indvidual atoms - and can image and take live videos of III-V nanowires and materials systems as they grow. Reine Wallenberg and Kimberly Dick Thelander (pictured) are two of four PIs behind the initiative backed by KAW and with support of NanoLund and LTH. Lars Samuelson and Jonas Johansson are the the other two PIs.

Photo credit: Laura Abariute

SUPER-RESOLUTION STED MICROSCOPE LABORATORY AT NANOLUND

Project leaders for the brand new STED operations in NanoLund are Jonas Tegenfeldt and Christelle Prinz, who gratefully received support of 5 MSEK from the Crafoord foundation and also from the ERC for this laboratory. Pictured on the left is Elke Hebisch, a NanoLund postdoc who did her PhD in the group of Stefan Hell who in 2014 received the Nobel Prize for his work on stimulated emission depletion (STED) microscopy. In the background is Jason Beech, researcher and lab responsible.

EDUCATION & 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 initated 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.

Siince the programme was instigated, there has always been less places than applicants, even though the last five years have seen a decline in application pressure due to a general downward trend in applicants to physcics subjects. Historically the gender balance fluctuates regularly from year to year with female participation between 18%-37% in the period 2008-2017.

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 are often widely distributed over the internet.

2017 ENGINEERING NANOSCIENCE STATS

61 Undergraduate applicants with the Nanoscience programme as their first choice, of which

56 offered a place

18.59 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)

1.4 Needed on national SAT equivalent (Swedish "högskoleprov", scale 0-2)

2017 OUTREACH STATS

90+ Online appearances

42 Popular science talks,

14 of which in high schools

13 Newsprint, TV, or radio items

3 Exhibitions

1 Theater play

GRADUATE EDUCATION

DOCTORAL THESES 2017

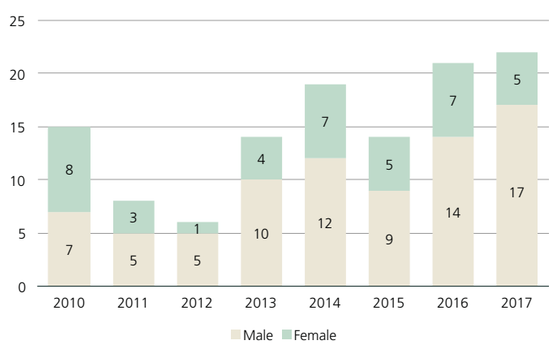
Adolfsson, Karl (Solid State Physics)	*GaP and GaInP nanowires as model particles for in vivo fiber toxicity studies*
Ahlberg, Erik (CEC, Nuclear Physics)	*Speeding up the Atmosphere: Exp. oxidation studies of ambient and laboratory aerosols using a flow reactor*
Aghaeipour, Mahtab (Solid State Physics)	*Tailoring the Optical Response of III-V Nanowire arrays*
Bauer, Patrik M. (Functional zoology)	*Effects of gold- and silver nanoparticles on the retina*
Bjerlin, Johannes (Mathematical Physics)	*Few- to many-body physics in ultracold gases: An exact diagonalization approach*
Damtie, Fikeraddis (Mathematical Physics)	*Probing Electron Collisions in Nanostructures*
Duarte, Mariana (Biomedical Engineering)	*Porous Polymers and Designed Sorbents for Applications in Biomedical Research*
Etemadi, Leila (Neuronano RC)	*Towards a Translational Pain Model - Techniques and developments*
Evertsson, Jonas (Synchrotron Radiation)	*Protective and Nanoporous Alumina Films Studied in situ by X-ray and Electrochemical Methods*
Jagadeesan, Kishore (Biomedical Engineering)	*High-throughput screening of solid-phase extraction materials using mass spectrometry*
Johansson, Niclas (Synchrotron Radiation)	*Synchrotron-based In Situ Electron Spectroscopy Applied to Oxide Formation and Catalysis*
Knutsson, Johan (Synchrotron Radiation)	*Atomic Scale Characterization of III-V Nanowire Surfaces*
Ludvigsson, Linus (Solid State Physics)	*Physical characterization of engineered aerosol particles*
Malkoc, Ognjen (Mathematical Physics)	*Entanglement detection schemes and coherent manipulation of spin in quantum dots*
Martinsson, Johan (CEC, Nuclear Physics)	*Development and Evaluation of Methods in Source Apportionment of the Carbonaceous Aerosol*
Merdasa, Aboma (Chemical Physics)	*Super-resolution Luminescence Micro-Spectroscopy: A nano-scale view of solar cell material photophysics*
Persson, Olof (Synchrotron Radiation)	*Development of new characterization techniques for III-V nanowire devices*
Taj, Tahir (Division of environmental and occupational health)	*Safe air below EU air quality limit? Studies of respiratory disease using primary health care data, with Case-Crossover study design*
Vainorius, Neimantas (Solid State Physics)	*Optical Studies of Polytypism in GaAs Nanowires*
Zota, Cezar (Nanoelectronics, EIT)	*III-V MOSFETs for High-Frequency and Digital Applications*
Öström, Emilie (CEC, Nuclear Physics)	*Modeling of new particle formation and growth in the atmospheric boundary layer*

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 22 PhDs graduated in 2017 and wish them all a brilliant career!

NanoLund PhD Theses 2010-2017



CORE VALUES

NANOLUND LAUNCHES CORE VALUES

The signature image on the right originates from our Annual Meeting in September where we launched and "signed up" for our core values represented by the three guiding words Openness, Enthusiasm and Pioneering. These three words, and the descriptions of what we mean by them and how we want them to be understood, are the result of a year-long process that engaged all of NanoLund and that featured many discussions of the scientific and personal culture we wish to have for our environment.

An excellent example for our values that can help guide important processes is the recent launch of the NanoLund Future Themes program that aims to identify and financially support new, major research themes. Specifically, this incentivises research initiatives that have the potential to pioneer NanoLund research into new areas of excellence, that offer openings for many NanoLund research groups to engage, and for which there is considerable enthusiasm – meaning many of us have a good gut feeling about the science and applications that may emerge. The NanoLund core values, summarized in our brochure "Who We Are", represent a go-to document for guiding principles in how we: act in our daily interactions, perform our research, direct our efforts and allocate our resources.

Photo credit: Laura Abariute

2017 NANOLUND AWARDS

Presentation of the 2017 NanoLund Young Teacher Award by Heiner Linke and Martin Leijnse. People from left to right: Martin Leijnse, Gaute Otnes, Linus Ludvigsson, Frida Lindberg and Heiner Linke

NANOLUND AWARD FOR EXCELLENT TECHNICAL AND ADMINISTRATIVE SUPPORT

The outstanding 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 recognises outstanding achievements for TAP personnel. This year's award was presented to:

- **Anders Kvennefors**, Research Engineer, Solid State Physics
- **Katarina Lindqvist**, Admin & Financial Officer, Mathematical 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 recognise extraordinary commitment to teaching by junior scientists. In 2017 they were presented to:

- **Fredrik Brange**, PhD student, Mathematical Physics
- **Frida Lindberg**, PhD student, Solid State Physics
- **Linus Ludvigsson**, PhD student, Solid State Physics
- **Gaute Otnes**, PhD student, Solid State Physics
- **Tinna Palmadottir**, PhD student, Biochemistry

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 2017 project call, ten projects were received and evaluated by a group of senior scientists and PhD students, with an emphasis on originality, feasibility and potential impact. Four projects were selected for funding by a one-time sum of 100000 SEK for research expenses:

- **Daniel Finkelstein-Shapiro**, Postdoc at Chemical Physics, for *Nanowire-gas interaction: from surface site probes to sensors*
- **Stefán Bragi Gunnarsson**, PhD student at Biochemistry and Structural Biology, for *Three dimensional imaging of proteins on nanowires*
- **Hanna Kindlund**, Postdoc at Solid State Physics, for *Atomic ordering in group III-V ternary semiconductor nanowires*
- **Pierre-Adrien Mante**, Postdoc at Chemical Physics, for *Nanowires for efficient terahertz emission*

Anders Kvennefors, Solid State Physics

Katarina Lindqvist, Mathematical Physics

INNOVATION

Image credit: Taiwan Semiconductor Manufacturing Co., Ltd

NANOPRODUCTS FOR THE FUTURE

NanoLund has always been an active breeding ground for new technologies, with startups coming from the environment amassing over 1.5 billion SEK in investments and and leading to over a thousand Full Time Equivalents in jobs in total so far.

Companies that have come from the NanoLund environment include: Glo AB, SolVoltaics AB, Obducat technologies, Qunano AB and Hexagem. The environment also interacts with a number of large and established companies every year, not the least through the Lund Nano Lab. The core of NanoLund's success in pushing nanotechnologies to market is a focus on nanowire science-based materials production platforms.

Researchers from NanoLund have invented *Aerotaxy*, a patented continuous and industrially scalable nanowire production technology which is the basis for SolVoltaic's products. The blue banner above is a microscope image of these nanowires. Researchers from NanoLund have also managed to produce zero-defect Gallium Nitride substrate materials, the technology basis for the company Hexagem and a key enabling technology which can be used, among other things, for direct-emitting LEDs and next-generation power electronics.

In order to accelerate the development of new nanotechnology and to fully leverage the competence and the innovation ecosystem around MAX IV and ESS, NanoLund is a key partner in the establishment of the ProNano pilot production infrastructure, managed by RISE and to be co-located with the new Lund Nano Lab in Brunnshög.

FUNDING

A great big
THANK YOU
to those who fund our research!

2016 INCOME IN MSEK

194 total income, of which

71 from the University and Strategic Research Area funding and

123 is external funding won in competitive calls. Breaking down the individual contributions there is about

36 from the Swedish Research Council (VR),

35 from the Knut and Alice Wallenberg foundation (KAW),

20 from EU H2020 funding including ERC,

17 from other Swedish funding agencies, (such as the Swedish Foundation for Strategic Research (SSF) and the Swedish Energy Agency),

8 from other grants,

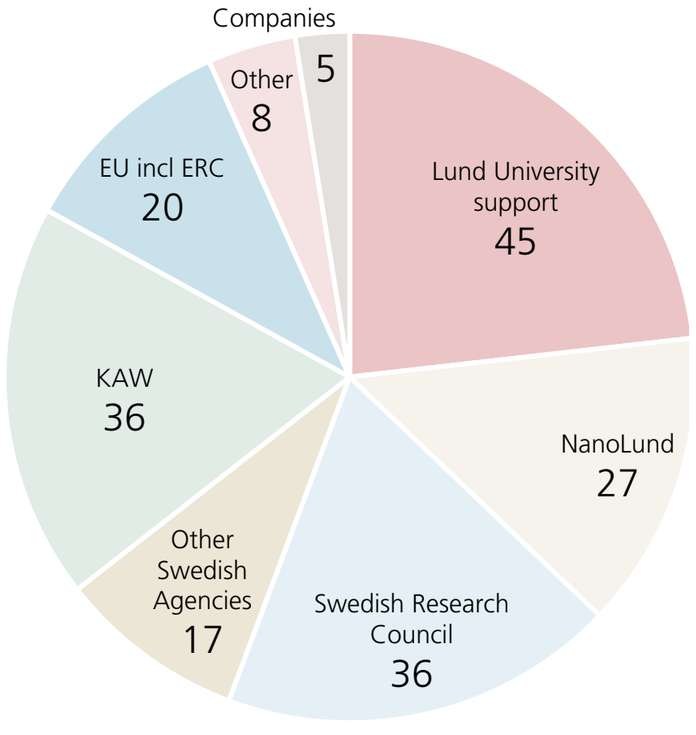
5 from companies.

NANOLUND INCOME FOR 2017

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 Incomes 2017 (MSEK)



EUROPEAN FUNDING

The NanoLund environment continues to apply for projects, individual funding, and to be active on a European level.

In 2017 members of NanoLund:

- Include 8 ERC awardees
- Participate in 14 EU projects
- Coordinate 5 EU projects, and 1 Marie Curie Individual Fellowship

LIST OF FUNDING BODIES

The Swedish Research Council
The Knut and Alice Wallenberg Foundation
European Commission's Research and Innovation Activities: European Research Council (ERC), Marie Sklodowska-Curie Actions, Horizon 2020 and FP7
The Swedish Foundation for Strategic Research
The Swedish Energy Agency
AFA Insurance
FORMAS
The LMK Foundation
VINNOVA
The Crafoord foundation
MISTRA
Alzheimerfonden
Barncancerfonden
Carl Tesdorps Stiftelse
Carl Tryggers stiftelse för vetenskaplig forskning
FORTE
Färs och Frosta Sparbank
Hasselbladsstiftelsen
Hjärnfonden
JIVESTEDT
KMA- Stiftelsen Kronprinsessan Margaretas Arbetsnämnd för sysnskadade
Kockska stiftelserna
Kungliga fysiografiska sällskapet
Magnus Bergvalls Stiftelse
Parkinssonfonden
Segerfalkstiftelsen
Sten K Johnssons stiftelse
Stiftelsen Olle Engkvist Byggmästare
STINT

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 six research areas:

- Materials Science
- Quantum Physics
- Nanoelectronics & nanophotonics
- Nanoenergy
- Nanobiology & nanoneuroscience
- Nanosafety

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

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.

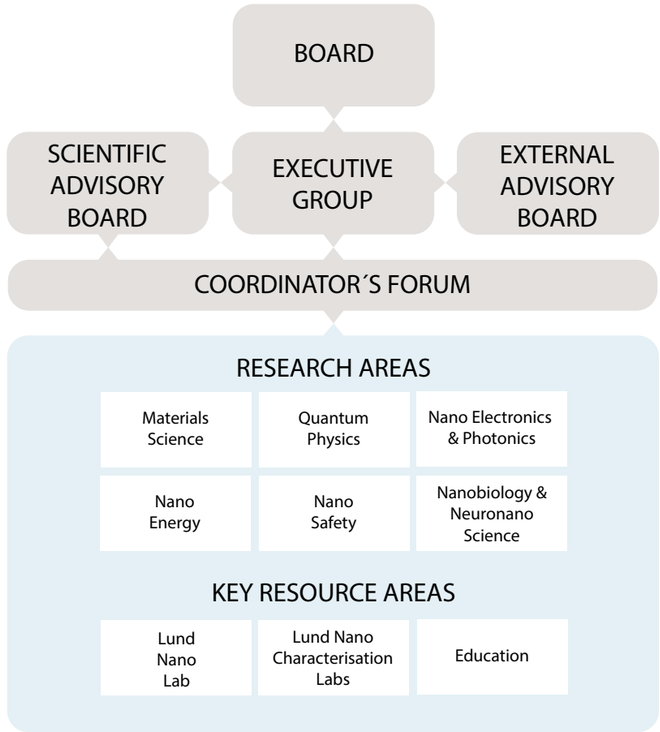
Nanomaterials industry
To establish an ecosystem that integrates education, research, R&D and pilot production to take ideas from research to the marketplace.

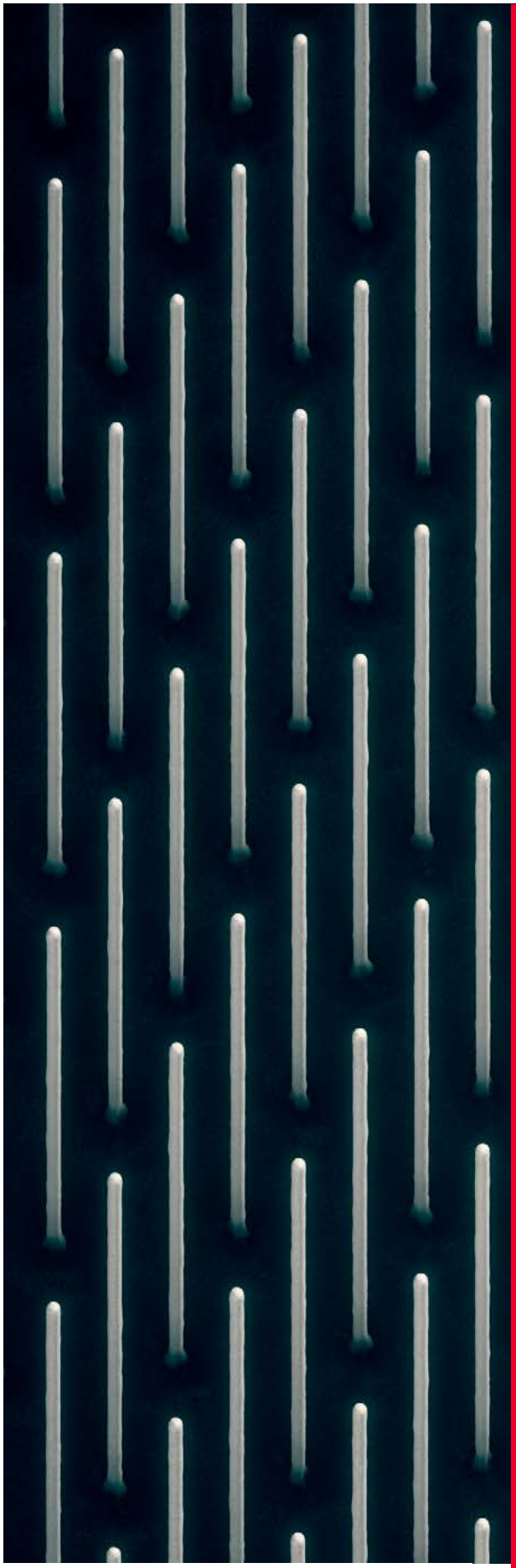
2017 NanoLund Board Members:
Viktor Öwall (Chair), Dean, LTH
Ulf Karlsson, Professor, Linköping U.
Frida Lindberg, Student rep.
Heiner Linke, Director, NanoLund
Sara Linse, Science faculty
Camilla Modéer, IVA
Stephanie Reimann, LTH
Regina Schmitt, Student rep.
Jens Schouenborg, Medical faculty
Reine Wallenberg, LTH
Tord Wingren, Huawei

2017 Executive Group:
Heiner Linke (Director)
Lars Samuelson (Vice-Director)
Anneli Löfgren (Co-Director)
Anders Mikkelsen (Co-Director)

2017 External Advisory Board:
Camilla Modéer (Chair), IVA
Ola Asplund, IF Metall
Sarah Fredriksson, Genovis AB
Peter Honeth, former State Secretary
Ulf Karlsson, Linköping University
Ilmar Reepalu, Region Skåne
Tord Wingren, Huawei

Coordinator's forum:
Consists of:
Executive group (4),
Chair of the Board,
Coordinators and co-coordinators of the subareas and resource areas,
Student representatives to the Board





INFO

This is the 2017 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 2017.

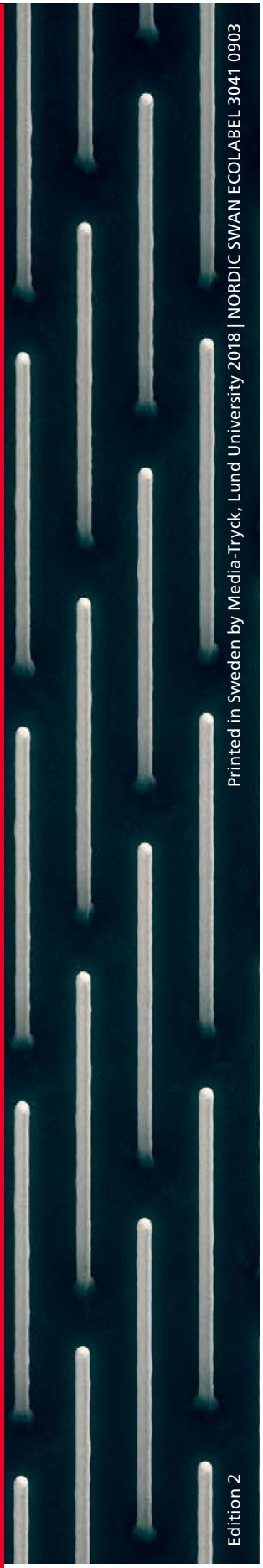
This report is based on material and data compiled and edited by the staff of NanoLund, in particular:

Line Lundfald
Communications and Coordination

Martin Stankovski
External Relations Officer

Anneli Löfgren
Administrative Director

Heiner Linke
Director



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Edition 2

LUND UNIVERSITY

NANO LUND

AT THE FOREFRONT OF NANOSCIENCE

LUND UNIVERSITY

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