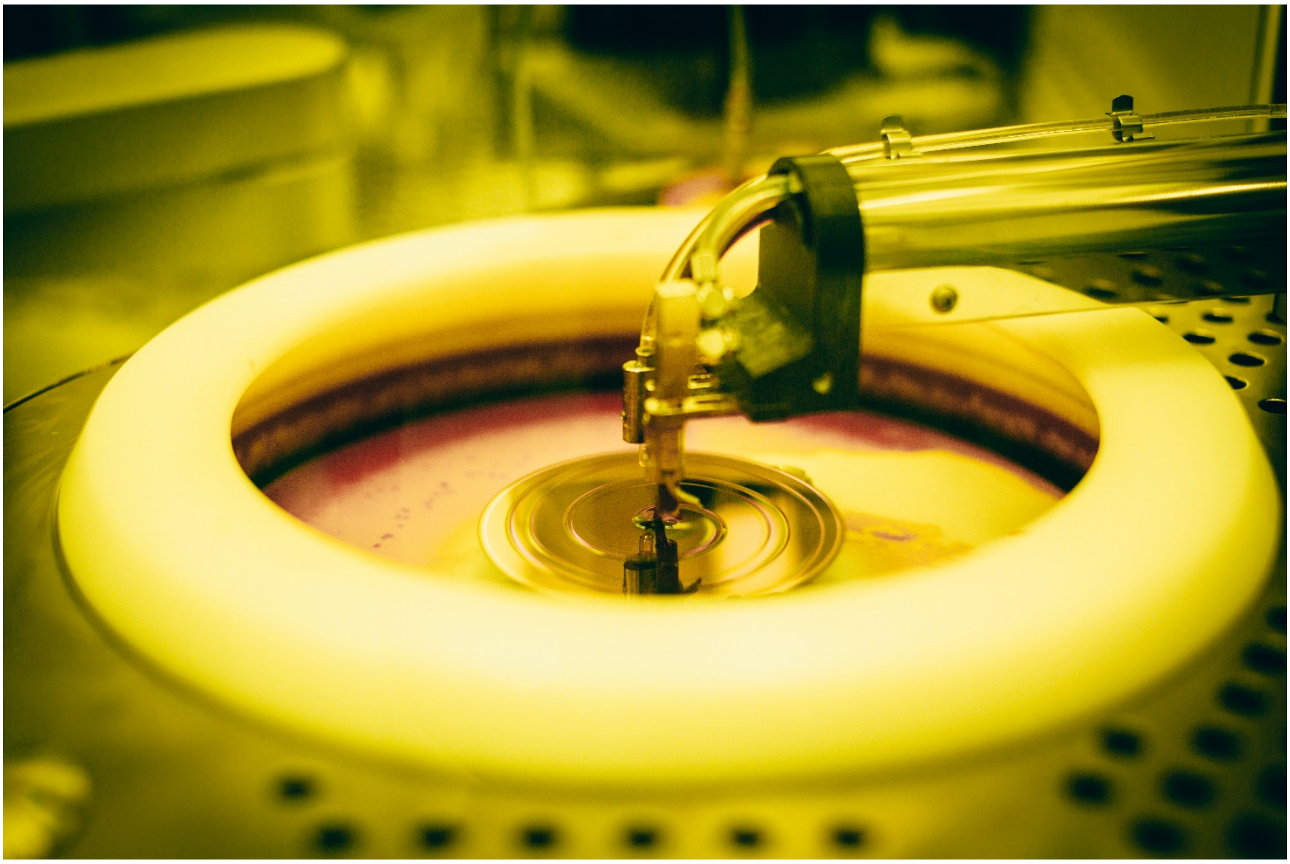
Myfab Report 2018

Myfab - The Swedish Research Infrastructure for Micro and Nano Fabrication
www.myfab.se



Myfab, founded in 2004, is a national facility since 2010 and is Sweden's open-access research infrastructure (RI) for micro and nano fabrication with cleanroom laboratories at Chalmers, KTH Royal Institute of Technology, Lund University and Uppsala University.

Myfab is the best possible environment for the development and fabrication of materials and device structures for advanced research in physics, materials science, nanoscience, chemistry, life sciences and nanoelectronics in Sweden. This is supported by the fact that, annually, more than 800 peer-reviewed publications and more than 50 PhD students emerge from the environment.

Myfab is the place where synthesis – or creation – of new materials, structures, devices and miniaturized systems on the nanoscale are made. Research at Myfab is multi- and cross-disciplinary, and the birthplace of ideas and the playground for their realization. Myfab is the starting point for value chains, where devices are integrated as key enabling components in a system.

Myfab fulfils its national responsibility, in 2018 serving an all-time high number of users, counting more than 850 users, with a permanent staff of 74 people (60 full-time equivalents), a total cleanroom area of 5400 m^2, and 700 tools for processing and characterization.

We offer charge based user access with practically no waiting time to experienced and new users, from academic institutions and industry. Myfab's clean-room staff and expertise serve the users by developing and maintaining processes and tools, and by providing educational courses, process advice and support.

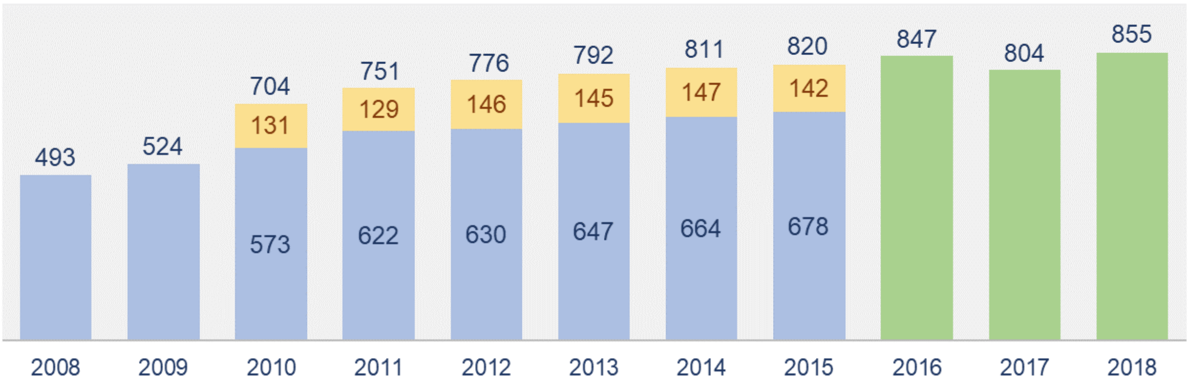
Further, Myfab is part of the Nordic Nanolab Network, where management, experts and users collaborate extensively in improving operations, process development, tool maintenance, user services, problem solving and by arranging common user meetings.

Myfab's distributed research infrastructure (RI) offers both the flexibility needed to advance state-of-the-art science and technology, as well as a quality assured environment for small and medium size manufacturing for spin-off companies and Small and Medium Sized Enterprises (SMEs). Today approximately 100 companies use Myfab, and during a 5-year period, typically 20 – 30 start-ups emerge from the environment.

The academic output from the Myfab environment is amazing: during the current financing period (*i.e*. during three full years, 2016–2018) Myfab's user community produced 2223 peer-review publications and 169 persons finalized their PhD studies within Myfab. Myfab has set the standard in Europe for efficient user access, follow-up and planning through our operations practices supported by the tailor-made Myfab LIMS system. Myfab LIMS itself, is continuously developed through a community formed by Myfab and five other national RI's in Finland, Norway, Ireland, France and Portugal.

Being Sweden's national research infrastructure for micro and nanofabrication, Myfab attracts a vast majority of Sweden's micro- and nanotechnology researchers and entrepreneurs within a wide range of fields. Myfab LIMS was introduced at all Myfab laboratories in 2008, and over the last decade we have seen an increase in number of active users as well as booked tool hours.

In 2018, 723 (85 %) users come from academia and 132 (15 %) were commercial users from either industry or research institutes. Myfab annually serves approximately 100 companies. The total number of booked tool-hours was 191280. New and potentially returning users, with no previous experience from Myfab, are invited to apply for funding for their first project through *Myfab Access*.



Myfab statistics – from Myfab LIMS: number of active users 2008 – 2018. Myfab Lund started using Myfab LIMS in 2010; their corresponding number of active users is presented in yellow on top of the blue bars for 2010 – 2015.

ORGANISATION

Myfab's owner group

Myfab is a joint undertaking of four universities: Chalmers University of Technology, KTH Royal Institute of Technology, Lund University and Uppsala University. Each university owns the local cleanroom laboratory. The owner group has been formed in order to address matters where Myfab's undertakings and the University's strategy overlap. The participating universities collaborate according to the Consortium Agreement, and according to the Main Contract between the host university (Chalmers) and the Swedish Research Council (SRC). The members of the owner group in 2018 were:

Representing Chalmers:	Professor Mikael Fogelström
Representing KTH:	Professor Carl-Mikael Zetterling
Representing Lund University:	Doctor Anneli Löfgren
Representing Uppsala University, Q1-Q2:	Professor Mikael Jonsson
Q3-Q4:	Professor Åsa Kassman

Myfab's steering group

Myfab's steering group consisted of the following members during 2018: Anne Borg, (Prof. Physics NTNU, Norway),), Susanne Holmgren (Prof. Emerita, University of Gothenburg), Mikael Jonsson (Prof. Uppsala University), Anneli Löfgren, (Admin. Research Director Lund Nano Lab), Henrik Thunman (Prof. Chalmers) Jonas Wallberg (Director ICT, the Association of Swedish Engineering Industries, Teknikföretagen), and Mikael Östling, (chairman, Prof. and Deputy President KTH)

Operational management

Myfab's operation is managed by the Director Thomas Swahn in collaboration with the laboratory managers Ivan Maximov (Lund University, Q1 and Q2), Maria Huffman (Lund University, Q3 and Q4), Peter Modh (Chalmers), Stefan Nygren (Uppsala University) and Nils Nordell (KTH). Cristina Andersson, Chalmers, acts as support systems officer and project manager.

Myfab LIMS

During 2018 we have continued to develop Myfab LIMS platform. One big effort has been to start to build a module for process management, i.e. to document process flows and for run sheet documentation. We now have an early alpha version of creating and storing the documentation. This module will by far be the most complex addition since the start of the development twelve years ago. This work will continue in 2019. During 2018 we have added one international cleanroom, University of Latvia, to the user community.

During fall of 2018 we have had discussions with Nanolab NL about implementing Myfab LIMS in all of their cleanrooms. We will in April 2019 have a meeting to finalize how to proceed.

OUR FOUR CLEANROOM LABORATORIES

Myfab Chalmers

The alternation of generations in the lab staff continues where we during 2018 retired two technicians and one senior research engineer. Only one position has so far been replaced, this due to the budget limitations from the reduced SRC funding this period. The retirements will continue during 2019 and 2020 where we need to replace at least four positions.

The ageing set of process tools in the cleanroom continues to shift our focus more towards service and repair and less time available to support our users. The situation is now getting critical and new investments have to be done even before funding has been secured. Nevertheless, during 2018 we set a new all-time high for the commercial activities in the cleanroom. The industry boom is clearly visible in both companies working with their own staff as well as commissioned work.

Myfab KTH

Myfab KTH consists of two cleanroom facilities. The Electrum Lab is run in collaboration with the industrial research institute RISE, and the Albanova Nano Lab is operated partly in collaboration with Stockholm University. From the beginning of 2018 Electrum Lab is part of the new KTH School of Electrical Engineering and Computer Science (EECS), formed by merging the ICT, EES and CSC schools.

KTH has established "KTH Infrastructures"; Electrum Lab and Albanova Nanolab are recognized as two of those. The operation model at Myfab will, where applicable, be used as a template for other KTH infrastructures. Hence, Myfab LIMS and the model for calculation of full cost pricing are currently evaluated for a broader implementation. As a KTH infrastructure, Electrum Lab and Albanova Nanolab have received KTH funding for new equipment with 3,5 MSEK and 1,5 MSEK, respectively.

IRnova has signed an agreement with KTH on cleanroom access at Electrum Lab. This business relationship was previously handled by RISE/Acreo. The CMP (Chemical Mechanical Planarization) process established within the SSF research infrastructure fellow project "CMP Lab" is open for external users. Processes are established for planarization of Si/SiGe, SiO2 and SiC. Processes for planarization of InP and metal containing layers, respectively, will be established in the next future. A process for parylene coating, using a SCS PDS 2010 Labcoter 2 tool is set up in a service area of the cleanroom. It will primarily support the MEMS user groups.

The extremely high summer temperatures in 2018 affected the control of both temperature and humidity in the laboratories. This, together with the fact that most fans are more than 30 years old, motivates a renewal of parts of the ventilation system.

The second phase of the H2020 Widening project CAMART2 is funded with 15 MEuro during a period of 7 years (2017-23) to develop the education, research, open access laboratories, and innovation system at Institute of Solid State Physics at University of Latvia. KTH and RISE participate in a consulting role as partners from advanced countries.

Myfab Lund

2018 has been a very busy year for Myfab Lund. Funding from LU, LTH, NanoLund and the LMK foundation have enabled us to make some much needed additions and upgrades to our equipment. During 2018, two research engineers have been hired, one senior research engineer has retired and one more will do so in 2019. Several new pieces of equipment have been installed in the cleanroom. Our characterization capabilities have been expanded with the addition of a new AFM which can also perform a variety of electrical measurements, a new stylus profilometer with mapping capabilities, a new Spectroscopic ellipsometer with a range from 200-2500 nm and offering various modes of analysis including an environmental cell, a Talbot Displacement Deep UV Lithography tool offering us unique capabilities for sub 100nm periodic structures on up to 4 inch diameter wafers and a very low power plasma ash tool. We have been able to purchase a new bonder and have also upgraded our electrical characterization equipment.

Participation of Myfab Lund staff in both SSF (this was extended for two more years) and EU NFFA-Europe projects continued throughout 2018.

To enable better communication between lab staff and users we purchased Confluence as a platform. We plan to launch it to all users by summer of 2019. Additionally, we started working on e-learning and creating training modules for users to augment our overall training efforts and safety routines. Another important activity for our Lab which is on-going, has been the increase in Company users using a variety of laboratory resources during 2018.

Finally, we continued supporting networking activities not only within Scandinavia but also within Europe.

Myfab Uppsala

A record number of new users were introduced during 2018. A total number of 105 new users means that in average two new individuals got access each week of the year. The total number of users (charged for access) also increased and exceeded 300 all four quarters.

Two staff members retired during 2018. Despite repeated recruitment efforts only one suitable replacement has so far been found and hired.

The new investment procedure, with parallel tracks for reinvestments and renewal, has resulted in procurement of a new FIB system, a few more basic tools and an upgrade of the lithography lab. A new optical profilometer was installed and an ion beam etcher was acquired from a nearby company. Additional upgrades of a couple of PVD systems and a dry etch tool have been decided.

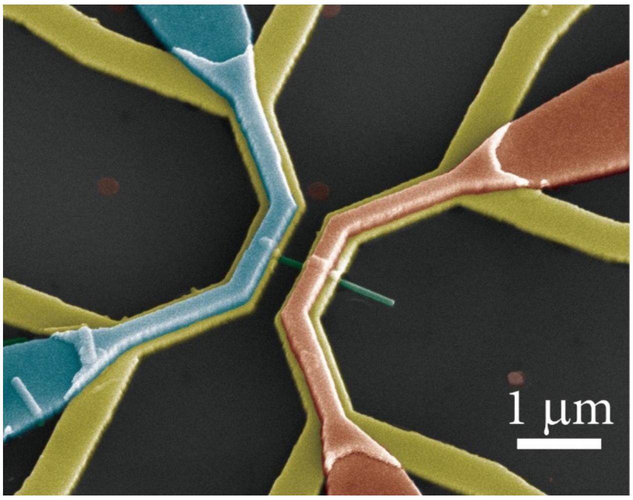
In order to highlight and distinguish our activity fields, a slight reorganisation into materials analysis / materials synthesis / materials structuring has been made.

SELECTED SUCCESS STORIES

Myfab is now a key enabler for experimental research in a number of strategic research areas (SRAs), introduced by the Swedish government (research bill 2008). These are of vital importance for Sweden and should be focused towards selected universities with the excellence and strength to take lead in the identified areas.

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

We realized direct heat-to-electric energy conversion at an efficiency of > 70% of Carnot efficiency, using energy filtering in a quantum dot. This is the culmination of a 10-year effort to demonstrate that this can be done. The results were published in Nature Nanotechnology including a front cover illustration of that issue. The success is enabled by (i) superior quality of heterostructure-defined quantum dots grown in Myfab Lund, and (ii) by innovative electric heater design, developed at Myfab Lund, which required state-of-the-art EBL and alignment. Our results demonstrate that thermoelectric power conversion can, in principle, be achieved close to the thermo- dynamic limits, with direct relevance for future hot-carrier photovoltaics, on-chip coolers or energy harvesters for quantum technologies.



False-coloured SEM image of an experimental device consisting of an InAs/InP nanowire QD in contact with metallic leads, as shown. Metallic leads (yellow) make contact to the nanowire (green). Heaters (blue and red) run over the contact leads and are insulated from them by a layer of high-k oxide. One of the heaters (red) is used in the experiment for thermal biasing, and the other (blue) is unused. The resulting $\Delta T = T_H - T_C$ *is set by the temperature profile of the phonon bath.*

M Josefsson, A Svilans, AM Burke, EA Hoffmann, S Fahlvik, C Thelander, M Leijnse & H Linke.
"A quantum-dot heat engine operating close to the thermodynamic efficiency limits"
(DOI: 10.1038/s41565-018-0200-5), Nature Nanotechnology 13, pages920–924 (2018)

Shape sorting of bacteria

To help better understand the underlying mechanisms controlling the change between the different shapes of bacteria (e.g. *Streptococcus pneumoniae*) and the effects of shapes on virulence, we have developed a microfluidic sorting device that fractionates a mixed bacterial population into subpopulations based on the shape of the bacteria. In this way, we have successfully demonstrated the purification of single cocci and diplococci as well as the enrichment of chains from a standard sample of cultured bacteria. In addition, we have demonstrated the fractionation into pure subpopulations of encapsulated and non-encapsulated bacterial strains from a mixed sample.

The devices are made using soft lithography based on a mould defined using UV-lithography. The mould is treated with fluorosilanes before PDMS silicone is poured to facilitate demoulding. Once the PDMS is cured, it is peeled off, treated with oxygen plasma, and sealed to a PDMS covered glass slide forming microfluidic channels. To avoid sticking of the bacteria, the device is first treated with PLL-g-PEG before introducing the sample. The experiments were run in our BSL2 facility using a computerized pressure controller for flow control and a standard inverted microscope for observation.

The work was performed together with our collaborators (group headed by Prof Birgitta Henriques-Normark) at the Karolinska Institute in Stockholm and was published recently (Ref). The work took place within the project LAPASO (EU FP7 project 607350). The devices were made in Myfab Lund.

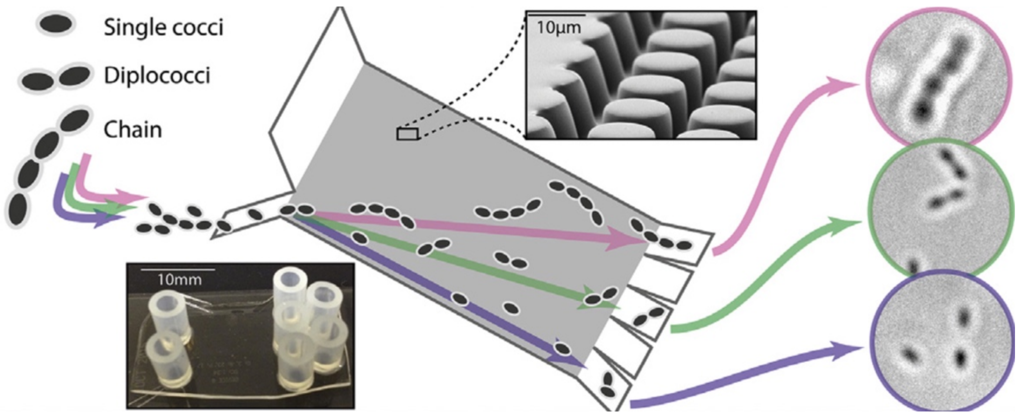


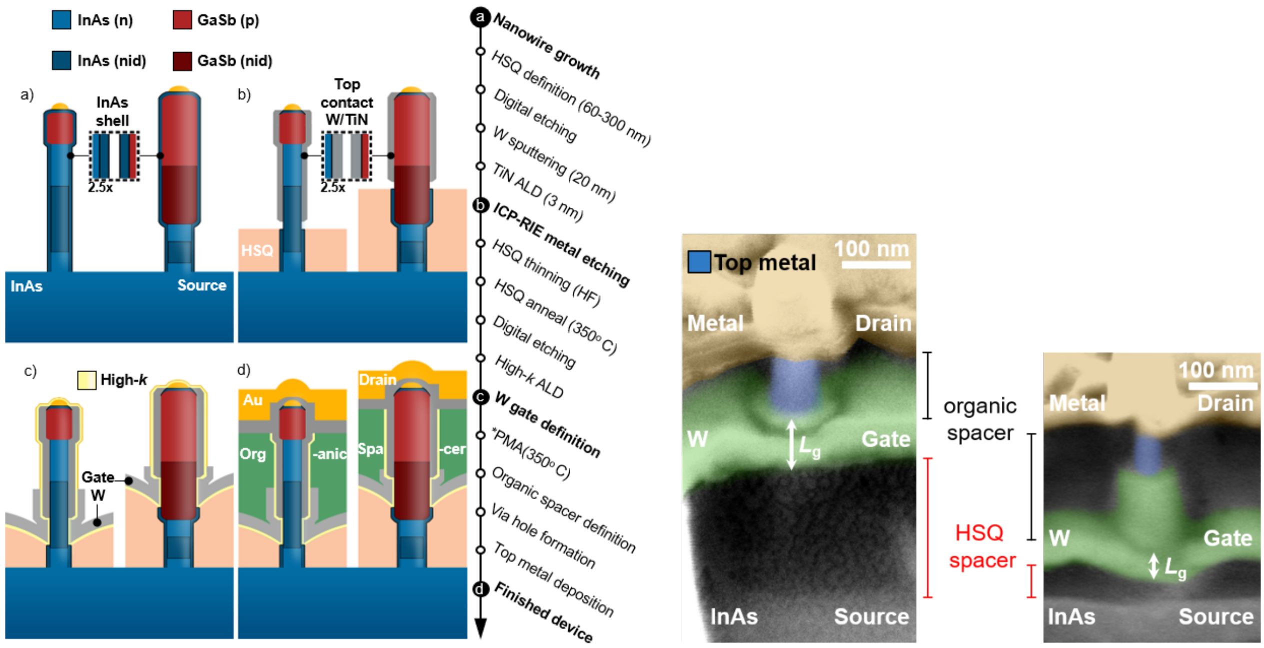
Figure 1. Graphic summary of the bacterial shape sorting project. A mixed population of the bacteria enter the device at the left-hand side in the small entrance channel. The trajectories of the bacteria now depend on the state of the bacteria. Single cocci move straight. Chains are entirely deflected. Diplococci move in intermediate trajectories.

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

Co-integrating III-V MOSFETS on Si

The nanoelectronics group at the department of electrical and information technology, Lund University, has in 2018 demonstrated a novel co-integration scheme for p- and n-type III-V MOSFETs on Si substrates, a step which is crucial for the development of an all III-V CMOS technology. Vertical nanowire n-type (InAs) and p-type (GaSb) transistors have been co-processed and co-integrated using a gate-last process, enabling small diameter (10-20 nm), short gate-lengths (Lg=40 nm) and low contact resistances. The process uses hydrogen silsequioxane (HSQ) spacers with a thickness defined by electron beam lithography to achieve a self-aligned process compatible with vertical antimonide-based structures. The transconductance achieved is 405 µS/µm for the NMOS and 230 µS/µm for the PMOS which is state-of-the-art for a GaSb MOSFET.

Jonsson, A., Svensson, J., & Wernersson, L. E. (2018). *A Self-aligned Gate-last Process applied to All-III-V CMOS* on Si. IEEE Electron Device Letters, 39(7), 935-938.
https://doi.org/10.1109/LED.2018.2837676



Left: Schematic illustration of crucial steps in the full process flow attached with an overview of fabrication. The illustrations show nid-channel devices, notice that the process allows for varying gate placement along the nanowire. Right: Colorized SEM-images depicting single nanowires inside a p-type and n-type structure, illustrating the different HSQ thickness.

Thermoelectric Characterization of the Kondo Resonance in Nanowire Quantum Dots

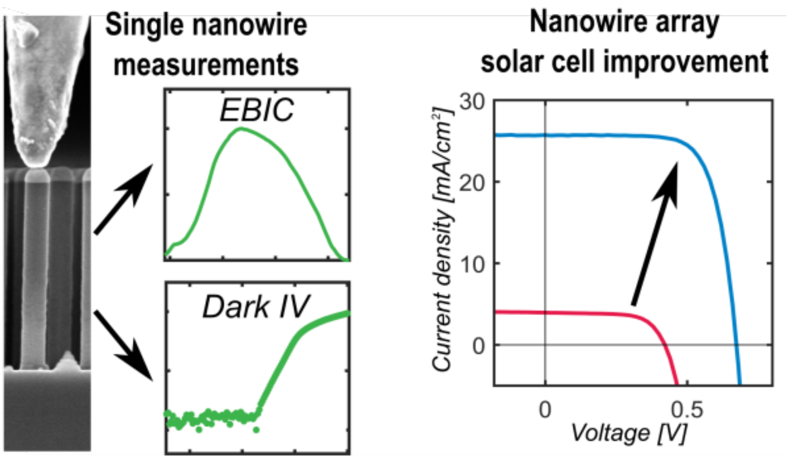
We experimentally verify hitherto untested theoretical predictions about the thermoelectric properties of Kondo correlated quantum dots (QDs). The specific conditions required for this study are obtained by using QDs epitaxially grown in nanowires, combined with a recently developed method for controlling and measuring temperature differences at the nanoscale. This makes it possible to obtain data of very high quality both below and above the Kondo temperature, and allows a quantitative comparison with theoretical predictions. Specifically, we verify that Kondo correlations can induce a polarity change of the thermoelectric current, which can be reversed either by increasing the temperature or by applying a magnetic field.

Svilans, A; Josefsson, M; Burke, AM; Fahlvik, S; Thelander, C; Linke, H; Leijnse, M, *Thermo-electric Characterization of the Kondo Resonance in Nanowire Quantum Dots,* Physical Review Letters, 2018, 10.1103/PhysRevLett.121.206801

Understanding Solar Cell Performance by Nanoprobe-Enabled Single Nanowire Measurements

We studied single as-grown InP nanowires by use of a recently installed electron beam induced current characterization tool in the Myfab Lund cleanroom to understand the charge carrier collection properties, and dark current-voltage characteristics to understand the diode recombination characteristics. By correlating the single nanowire measurements to performance of fully processed nanowire array solar cells, we identified how the performance limiting parameters were related to growth and/or processing conditions. We used this understanding to achieve a more than sevenfold improvement in efficiency of our InP nanowire solar cells. The best cell shows a certified efficiency of 15.0%, the highest reported value for a bottom-up synthesized InP nanowire solar cell [ref].

The use of single nanowire electron beam induced current characterization holds great potential in accelerating the development towards high performing nanowire solar cells, also in complex tandem geometries, as well as other nanowire devices such as photodetectors, light emitting diodes and lasers.



Otnes, Gaute; Barrigon, Enrique; Sundvall, Christian; et al.: *Understanding InP Nanowire Array Solar Cell Performance by Nanoprobe-Enabled Single Nanowire Measurements,* Nano Letters 18 Pages: 3038-3046 (2018)

Desalination of brackish water

Joydeep Dutta and his team works with the development of fundamental understanding of nanomaterials that will be able to reduce pollutants in air and water and to serve as alternative energy sources such as solar cells and the production of hydrogen. Specific examples are photocatalytic cleaning of phenol from water using nanoparticles, effective systems for water desalination, applications for pressure sensors and new super hydrophobic surfaces. The application of nanotechnology in water desalination gives a possibility to address the problem with depleting fresh water sources across the world. The technology of capacitive deionization is an energy efficient option for the desalination of brackish water. Through the development of an improved membranes technology based on nanotechnology for capacitive deionization, the costs for investment and operation of a full scale desalination plant is expected to be considerably reduced as compared to the conventional reverse osmosis desalination.

Dutta, Joydeep; Kunjali, Karthik Laxman *"DESALINATION DEVICE AND METHOD OF MANUFACTURING SUCH A DEVICE"* PCT Patent: 2018 (application no. PCT/EP2018/066435; filing date: 20th June 2018; public: 27 Dec 2018)

Laxman, Karthik; Kimoto, Daiki; Sahakyan, Armen; Dutta, Joydeep *"Nanoparticulate Dielectric Overlayer for Enhanced Electric Fields in a Capacitive Deionization Device"* ACS Applied Materials and Interfaces 1944-8244 vol. 10 (2018) p.5941-5948, ISI 000425572700090

Shafiq, Muhammad; Laxman, Karthik; Dutta, Joydeep: *"Estimation of ion adsorption using iterative analytical model in capacitive deionization process",* Desalination and Water Treatment 1944-3994 vol. 116 (2018) p.75-82, ISI 000445130100008

Quantum photonic circuits

The research group of Val Zwiller develops nanoscale quantum devices to generate, manipulate and detect single photons. Hence, advanced quantum circuits, where quantum dots, waveguides, filters and detectors are combined to form complex systems to explore new schemes in quantum sensing, communication and computing. The aim is to demonstrate new quantum sensing techniques and explore all facets from fundamental to technological implementations. The group explores a hybrid and scalable approach, where single III–V quantum emitters are positioned and integrated in a metal–oxide–semiconductor-compatible photonic circuit, marking an important step to harvest quantum optical technologies' full potential.

Chi, Xiaoming; Zou, Kai; Gu, Chao; Zichi, Julien; Cheng, Yuhao; Hu, Nan; Lan, Xiaojian; Chen, Shufan; Lin, Zuzeng; Zwiller, Val; Hu, Xiaolong: *"Fractal superconducting nanowire single-photon detectors with reduced polarization sensitivity",* Optics Letters 0146-9592 vol. 43 (2018) p.5017-5020, ISI 000447265700042

Elshaari, Ali W.; Buyukozer, Efe; Zadeh, Iman Esmaeil; Lettner, Thomas; Zhao, Peng; Schöll, Eva; Gyger, Samuel; Reimer, Michael E.; Dalacu, Dan; Poole, Philip J.; Jöns, Klaus D.; Zwiller, Val:*"Strain-Tunable Quantum Integrated Photonics",* Nano letters (Print) 1530-6984 vol. 18 (2018) p.7969-7976, ISI 000453488800074

Mukhtarova, Anna; Redaelli, Luca; Hazra, Dibyendu; Machhadani, Houssaine; Lequien, Stephane; Hofheinz, Max; Thomassin, Jean-Luc; Gustavo, Frederic; Zichi, Julien; Zwiller, Val; Monroy, Eva; Gerard, Jean-Michel: *"Polarization-insensitive fiber-coupled superconducting-nanowire single photon detector using a high-index dielectric capping layer",* Optics Express 1094-4087 vol. 26 (2018) p.17697-17704, ISI 000436226800140

Schweickert, Lucas; Jöns, Klaus D.; Zeuner, Katharina D.; da Silva, Saimon Filipe Covre; Huang, Huiying; Lettner, Thomas; Reindl, Marcus; Zichi, Julien; Trotta, Rinaldo; Rastelli, Armando; Zwiller, Val: *"On-demand generation of background-free single photons from a solid-state source",* Applied Physics Letters 0003-6951 vol. 112 (2018) p.-, ISI 000427022500038

Electronic circuits and Homogenous Integration

At Myfab new knowledge and inventions forming an entirely new generation of devices and electronic solutions are developed. These are instrumental for the establishment of e.g. Internet of Things (IoT), Artificial Intelligence and Industry 4.0, and will help Sweden to maintain its leading position within these high technology areas. Per-Erik Hellström develops a new generation of heterogeneous integrated circuits, where CMOS electronics are monolithically integrated in 3D with non-conventional devices (e.g. biosensors, chemical sensors, energy harvesters, optical components…), enabling almost any IoT application. Carl Mikael Zetterling and his group explore new solutions for high power, high temperature and radiation stable devices, based on the material silicon carbide (instead of the conventional silicon), making it possible to place fully operational electronics in hostile environments and functional over a wide temperature range of -40 to 600 °C. Hence a wide range of digital and analog devices have been demonstrated, which opens up for applications in combustion monitoring, deep well drilling and space missions to the inner planets, etc.

Shakir, Muhammad; Hou, Shuoben; Malm, Bengt Gunnar; Östling, Mikael; Zetterling, Carl-Mikael *"A 600 degrees C TTL-Based 11-Stage Ring Oscillator in Bipolar Silicon Carbide Technology"* IEEE Electron Device Letters 0741-3106 vol. 39 (2018) p.1540-1543, ISI 000446449300014

Kargarrazi, S.; Elahipanah, Hossein; Rodriguez, Saul; Zetterling, Carl-Mikael *"500 °c, High Current Linear Voltage Regulator in 4H-SiC BJT Technology"* IEEE Electron Device Letters 0741-3106 vol. 39 (2018) p.548-551, ISI 000428689000022

Jayakumar, Ganesh; Hellström, Per-Erik; Östling, Mikael *"Monolithic Wafer Scale Integration of Silicon Nanoribbon Sensors with CMOS for Lab-on-Chip Application"* Micromachines 2072-666X vol. 9 (2018) p.-, ISI 000451314900007

Abedin, Ahmad; Zurauskaite, Laura; Asadollahi, Ali; Garidis, Konstantinos; Jayakumar, Ganesh; Malm, B. Gunnar; Hellström, Per-Erik; Östling, Mikael *"Germanium on Insulator Fabrication for Monolithic 3-D Integration"* IEEE Journal of the Electron Devices Society 2168-6734 vol. 6 (2018) p.588-593, ISI 000435505000007

Terahertz devices

Devices for terahertz frequencies will be instrumental for a wide variety of applications, including car radar systems for autonomous driving and advanced satellite applications. Joachim Oberhammer, holder of an ERC grant, and his researchers are currently leading the research edge on several topics in micromachining for terahertz-frequency devices, and several record-breaking devices have been presented in recent years. A vision is to construct complete terahertz systems on single microchips, which consist of micromachined waveguides with integrated micromachined THz components. This new approach to THz systems could revolutionize the scientific and commercial exploitation of the terahertz frequency spectrum.

Beuerle, Bernhard; Campion, James; Shah, Umer; Oberhammer, Joachim *"A Very Low Loss 220–325 GHz Silicon Micromachined Waveguide Technology"* IEEE Transactions on Terahertz Science and Technology 2156-342X vol. 8 (2018) p.248-250, ISI 000426705300014

Shah, Umer; Liljeholm, Jessica; Campion, James; Ebefors, Thorbjörn; Oberhammer, Joachim *"Low Loss High Linearity RF Interposers Enabled by Through-Glass Vias"* IEEE Microwave and Wireless Components Letters 1531-1309 vol. 28 (2018) p.960-962, ISI 000450161400002

Smirnov, Serguei; Anoshkin, Ilya V.; Demchenko, Petr; Gomon, Daniel; Lioubtchenko, Dmitri V.; Khodzitsky, Mikhail; Oberhammer, Joachim *"Optically controlled dielectric properties of single-walled carbon nanotubes for terahertz wave applications"* Nanoscale 2040-3364 vol. 10 (2018) p.12291-12296, ISI 000438246000006

INTERNATIONAL COLLABORATION

Myfab is part of the Nordic Nanolab Network (NNN), which encompasses collaboration at the management-, expert- and user levels in all five Nordic Countries. In addition to being geographically close, the Nordic research infrastructures are similar to Myfab in organization and have similar missions. The NNN members, i.e. Myfab, the Norwegian research infrastructure NorFab, DTU Nanolab in Denmark, VTT Micronova/Aalto Nanolab in Finland, and the University of Iceland form a regional infrastructure alliance within which we learn from each other by sharing best practices, every 2:nd year arranging the Nordic Nanolab User Meetings, as well as addressing tasks that are strategically important for all members. These include *i).* Simplifying the exchange of users between the Nordic countries by unifying the access routines, simplifying the exchange of wafers and materials between the laboratories and establishing a common e-learning system for all users, *ii).* Making research within nanotechnology more efficient, by documenting and exchanging fabrication processes between the laboratories, and *iii).* Supporting open science, by developing a way of publishing research results within nanofabrication. NNN held two management meetings during 2018, hosted by Norway in March and Denmark in September.

The Nordic Nanolab Expert Network (NNEN)

The NNEN consists of expert groups with members from the Nordic countries and organized in five topical areas: dry etching, thin films, lithography, characterization (in cleanrooms) and facility management. Each NNEN technology group has about 20 active members and meets twice per year with lunch-to-lunch meetings. The NNEN activities is a very efficient way of promoting staff competence development in the most relevant areas for a research infrastructure and its users.

ECONOMY

Myfab's financial report for 1 January – 31 December 2018, submitted separately and undersigned by Chalmers financial controller, has been delivered to the Swedish Research Council. The report presents how the Myfab operations grant has been distributed, in accordance with the decisions taken by Myfab's steering group. The table below present the total economy of the Myfab laboratories and sets the Myfab operation grant in perspective to each laboratory's total economy. The Myfab grant in this table represents the full-year 2018.

Income [kSEK]	**Myfab Chalmers**	**Myfab KTH**	**Myfab Lund**	**Myfab Uppsala**	**Myfab all four labs**
Faculty grants	25 790	14 800	17 471	10 871	**68 932**
Fees, academic	17 356	13 300	12 921	15 062	**58 639**
Fees companies incl. RISE	8 732	24 700	2 671	2 998	**39 101**
Myfab SRC grant	3 350	3 270	3 277	3 277	**13 174**
Financed depr.	4 572	1 500	5 538	5 671	**17 281**
Projects SSF, EU		4 400			**4 400**
Services	122	1 250	3 275		**4 647**
Income Total	**59 922**	**63 220**	**45 153**	**37 879**	**206 174**
Costs [kSEK]					
Personnel	15 254	15 000	10 708	7 917	**48 879**
Rent premises	17 388	9 400	9 550	13 990	**50 328**
Operation	12 594	25 700	10 249	10 049	**58 592**
Overhead	4 782	8 800	6 476	2 464	**22 522**
Financed depr.	4 572	1 500	5 538	5 671	**17 281**
Depreciations	4 479	2 800	7 147	1 537	**15 963**
Costs Total	**59 069**	**63 200**	**49 668**	**41 628**	**213 565**
Result	**853**	**20**	**-4 515**	**-3 749**	**-7 391**

ANNEXES

A. Standard report from Myfab LIMS – key numbers for Myfab 2018
B. Key numbers as specified from Appendix 1 (Bilaga 1) to Myfab's contract (Dnr: 2015-06030)
C. Publication lists from Publication lists from Myfab's laboratories at Chalmers, KTH Royal Institute of Technology, Lund University and Uppsala University

ANNEX A

Standard report from Myfab LIMS – key numbers for Myfab 2018

	Chalmers	KTH	Lund	Uppsala	2018 Myfab	2017 Myfab	2016 Myfab	2015 Myfab	2014 Myfab
Users with access	455	464	209	440	**1658**	1611	1592	1476	1412
Active users	203	217	151	284	**855**	804	847	820	811
Female active users	43	49	39	93	**224**	198	211	193	197
Gender balance, active users	21%	23%	27%	33%	**26%**	25%	25%	24%	24 %
University active users	174	167	129	252	**723**	669	716	695	672
Institutes active users	1	7	1	2	**11**	11	12	11	22
Commercial active users	27	43	21	30	**121**	124	119	113	117
Companies with own personnel	11	18	5	22	**56**	56	59	50	54
Number of booked hours	61141	38067	53651	38420	**191280**	195615	199303	192802	177732
-from universities	55290	27244	51363	34987	**168885**	170101	170980	166520	146940
-from institutes	54	2158	28	84	**2323**	3220	3630	3169	11709
-from commercial users	5797	8665	2260	3349	**20072**	22293	24694	23099	19155
Number of tools	190	237	90	189	**706**	709	697	683	654
Booked tools	138	109	68	93	**408**	404	399	407	381

ANNEX B

Key numbers as specified from Appendix 1 (Bilaga 1) to Myfab's contract (Dnr: 2015-06030)

1). Number of users per Myfab site, including other organisations, companies etc.

See the standard report in Annex A.

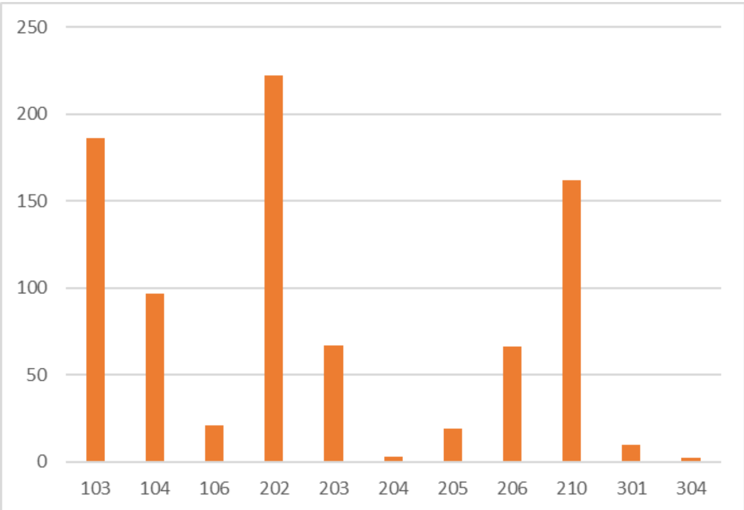
2). Number of users per scientific area (SCB-codes, on the 3-digit level)

Number of active users 2018:

During 2018 the Myfab infrastructure hosted 855 active user individuals (making at least one tool booking). Considering all activities connected to this lab work, such as theoretical modelling, computer simulations, device evaluations, etc., the total number of scientists and developers benefitting from the infrastructure can be counted in thousands. Among the active users, 85 % (723) were academics, accounting for 88 % of the utilization. The gender balance is still not equal, with only 26 % female active users.

On-site industrial users represent about 50 companies, most of which are spin-out companies or small SMEs needing cleanroom, tools and process lines to advance their innovations. This number is doubled (about 100) if remote user companies are included.

The distribution of active users in various research areas (SCB standard) is presented below. As this diagram clearly indicates, our users are active in many different disciplines but basic science, electrical engineering and nanotechnology dominate.



103 Physical Sciences
104 Chemical Sciences
106 Biological Sciences
202 Electrical Engineering
203 Mechanical Engineering
204 Chemical Engineering
205 Materials Engineering
206 Medical Engineering
210 Nanotechnology
301 Basic Medicine
304 Medical Biotechnology

3). Number of female and male users

Total number of active users 2018: 855
Total number of female active users 2018:224 (26 %)
Total number of male active users 2018: 631 (74 %)

4). Average number of individuals that are connected to a group leader ("PI")

Not available from Myfab data. User affiliation normally recorded on department and division level.

5). Number of users per laboratory (i.e. active users 2018)

Myfab Chalmers	203
Myfab KTH	217
Myfab Lund	151
Myfab Uppsala	284

6). Number of users that has applied for access to the infrastructure but were not given access

No users were denied access. Myfab applies open user access based on user-fees. The access model, according to "European Charter for Access to Research Infrastructures", European Commission (ISBN 978-92-79-456) is denoted Market-driven access. All users who are qualified, i.e. have the appropriate education and approval from an established research group (liable for all user charges), are given access to the infrastructure. Myfab gives regularly relevant clean-room and tool educations to its users.

7). Number of driver's licenses (individuals) that has passed the compulsory education and are allowed to use the laboratory, reported per laboratory

Total number of users with access:	1658
Myfab Chalmers:	455
Myfab KTH:	464
Myfab Lund:	299
Myfab Uppsala:	440

8). Number of scientific publications and patents, published 2018 and to which the infrastructure has contributed

Number of scientific publications, (journal and conference papers) and PhD exams

	Publications	PhD exams
Myfab total:	672	64
Myfab Chalmers:	162	8
Myfab KTH:	188	12
Myfab Lund:	76	18
Myfab Uppsala:	246	26

Number of patents: Myfab does not have information on user's patents, nor does Myfab require its users to report this kind of information.

ANNEX C

Publication lists from Publication lists from Myfab's laboratories at Chalmers, KTH Royal Institute of Technology, Lund University and Uppsala University

Myfab Publications 2018

Journal and Conference Papers

Myfab Chalmers

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6. Damiano Verardo, Lightguiding of Fluorescence in Nanowires
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9. Laura Abariute, Engineered nanomaterials in in vivo and in vitro models
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12. Rong Sun, Understanding the Role of Seed Particle Material on III-As Nanowire Growth
13. Stefan Gunnarsson, Nanostructure and biomolecule interactions
14. Stefan Holm, Microfluidic Cell and Particle Sorting using Deterministic Lateral Displacement
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