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Myfab Report 2021

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

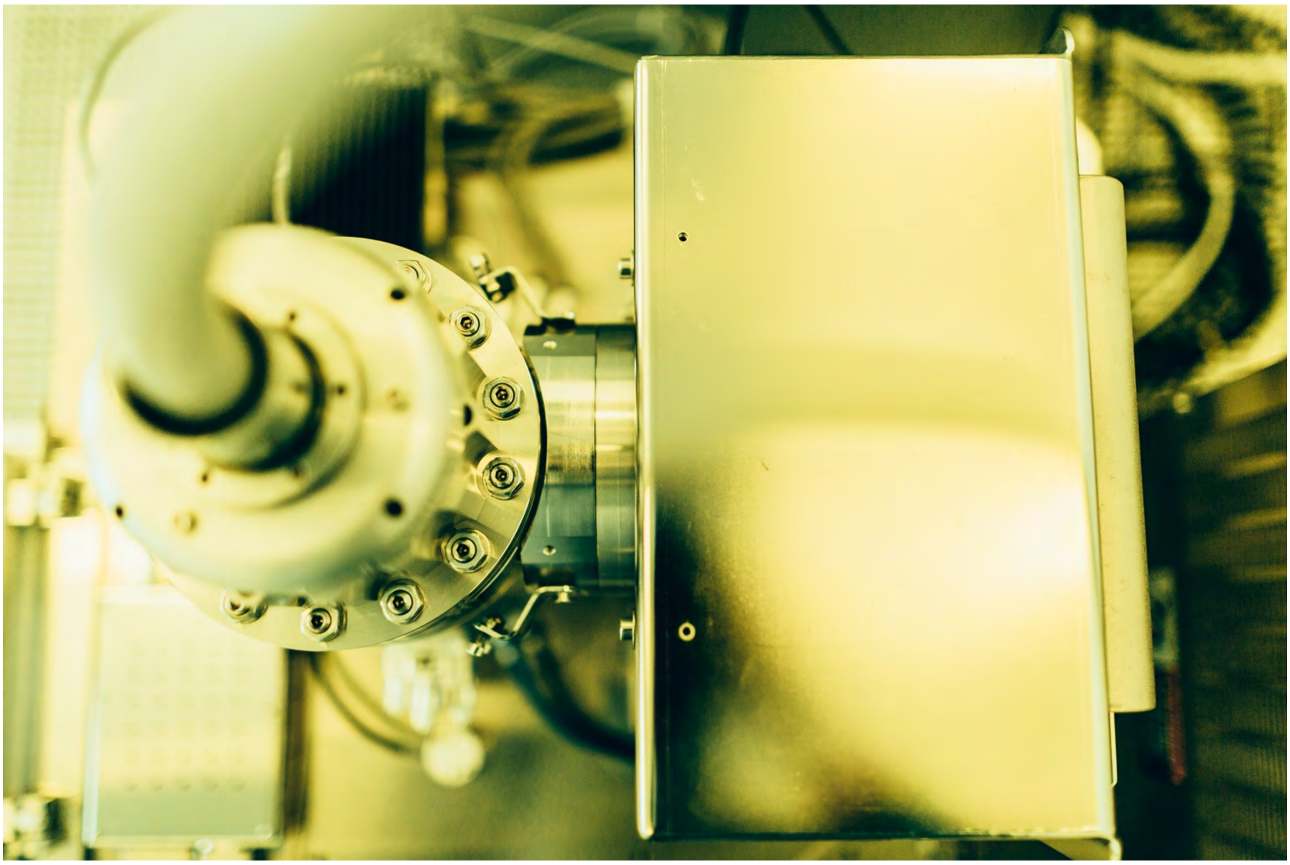
INTRODUCTION

Myfab, founded in 2004, is a national facility since 2010 and is Sweden's open-access research infrastructure (RI) for micro a nd nano fabrication with four cleanroom laboratories: Myfab Chalmers, Myfab KTH, Myfab Lund and Myfab Uppsala.

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.

From the Myfab environment 745 publications and 61 doctorial theses were produced during 2021, and during the six-year period 2016 – 2021, 4441 peer-reviewed publications and 333 PhD students have emerged, which demonstrate Myfab's capability for the development and fabrication of materials and device structures for advanced research in Sweden.

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 brings together Sweden’s leading nanofabrication labs under a common umbrella, creating a national resource that makes a permanent staff member of 75 people (61 full-time equivalents), a total of 5400 m^2 of clean room area, more than 700 tools and processes openly available to researchers around Sweden and internationally, with the aim of ensuring

Sweden's competitiveness in important research areas. In 2021 the national infrastructure had 817 unique users.

We offer user-fee 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

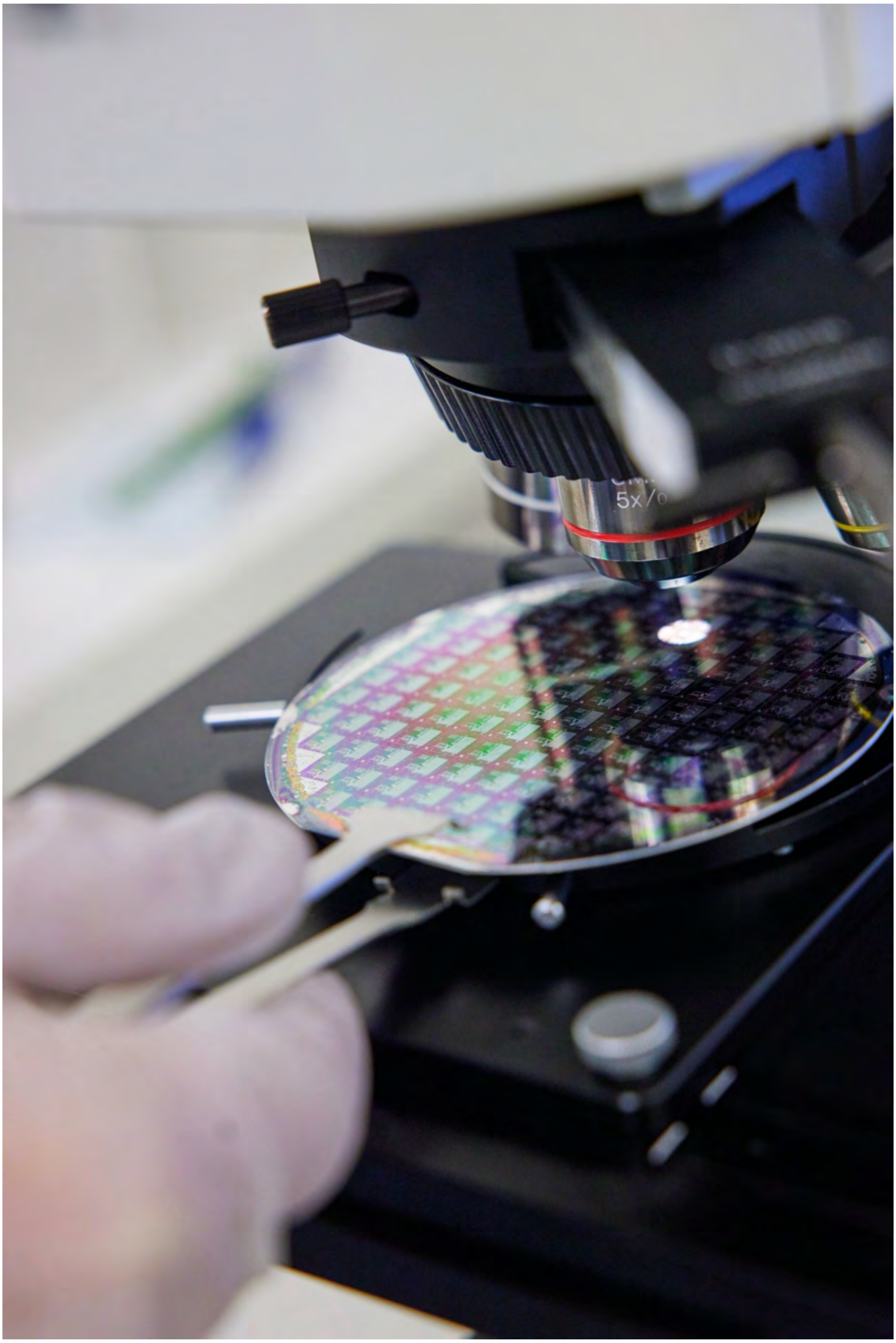
Enterprises (SMEs). Today more than 100 organisations use Myfab, 85 of them are companies. During a 5-year period, typically 20–30 start-ups emerge from the environment.

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 six other national RIs in Finland, Norway, Ireland, France, Portugal and Latvia, and a cleanroom labooratory in Spain. The system is used by 18 cleanrooms in total, and we have a dozen other lab infrastructers at Swedish Universities that run the system.

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 twelve years since it has assisted users to access to the whole infrastructure and provided important information to management for both operations and strategic development of the infrastructure.

2021 is the second pandemic year and compared with 2019 we still have reduced headcount which is attributed to the Covid-19 associated restrictions. Compared to the pre-pandemic year 2019, we see a drop with 8,8 % in laboratory usage during 2021 (up from -11,9% in 2020), at the same time we see a decrease of the commercial usage (booked hours) with 2,8 % from 2020 to 2021, and after the significant increase with 11,4 % 2019 – 2020. Compared to 2020 we have an increase by 3,7% in the number of users and 3,5 % in number of booked tool hours (170 579). Currently 660 (81 %) users come from academia and 151 (19 %) were commercial users from either industry or research institutes.

New and potentially returning users, with no previous experience from Myfab, are invited to apply for funding for their first project through Myfab Access.The academic users cover a broad range of scientific areas, several are international users from various universities. The non-academic users come from industry or institutes, and use our infrastructure for production, product development, or for carrying out research projects. Myfab offers, especially important to small and medium sized companies, a unique possibility for access to micro- and nanotechnology tools and expertise. Myfab has often been the launching point for a number of spin-off companies emanating from the research environments using the infrastructure. These spin-offs create an immense societal impact, and we estimate that their total turnover is well beyond one billion SEK per year.



14 MSEK ADDITIONAL FUNDING FOR INVESTMENTS 2021

Myfab received an investment grant (Dnr. 2021-00278) from the Swedish Research Council for investment in a pulsed laser deposition (PLD) equipment, including in-situ RHEED characterization (6 MSEK), to be installed at Myfab Lund, and for an ultra high vacuum physical vapor deposition (UHV-PVD) tool (8 MSEK) to be installed at Myfab Uppsala. The total investment for this package is 14 MSEK.

COVID-19 PANDEMIC PRECAUTIONS

The Covid-19 pandemic has forced Myfab to introduce new routines to minimize the spread of the virus. Myfab's cleanroom laboratories have followed all rules and recommendations given by the Public Health Agency of Sweden as well as the rules set up by the host universities. Generally, during most of 2020–2021 the universities have recommended that as much as possible work should be carried out from home, but at the same time, necessary laboratory work has been allowed. The presence of Myfab's staff at the laboratories has been reduced, and new routines to secure distancing between uses have been implemented.

We interpret that the 8,8 % reduction in total lab usage in 2021 compared to 2019 as a direct effect of the pandemic, the recommendations to work from home and defering non-critical work. The increased commercial usage is interesting and a bit surprising since is happened during a pamdemic. Obvisually, Myfab offers possibilities that are attractive and prioritized even during a pandemic.

GOVERNANCE DURINGTHE CURREN PERIOD OF OPERATION 2020 - 2024

Myfab's fifth period of operation started on 1 January 2020 and is promoted by a new model for governing national research infrastructures. Common for all national research infrastructures in Sweden since 2020 is that they have a governing board, the General Assembly (GA or Stämman in Swedish), which is in charge of general conditions including the consortium agreements and commitments of the participating universities. Myfab's GA thus consists of four members, one each from Chalmers (host), KTH, Lund University and Uppsala University respectively. The GA meets at least once per year.

The Steering group, with members recommended by the General Assembly and appointed by Chalmers University of Technology (Chalmers), consists of seven members. Four of them are representatives proposed by the participating universities, one is an industrial representative, one international representative and finally one from another Swedish university. The steering group oversees Myfab's activities during the current period of operation, which ends on 31 December 2024. The steering group normally has four physical meetings each year, where the director also participates. The steering group decides on the use of the SRC funding and takes strategic decisions on Myfab's activities. Through this process we make sure that operations and strategic development are aligned and support the need of our users in the best possible way.

The director is in charge of operations and to implement the decisions by the steeringgroup. The operational management consists of the director and the four laboratory managers and oversees day-to-day operation and collaboration with the steering group and the owner group. The over-all structure of Myfab's management gives a balance between the bodies involved.

MYFAB LIMS

During 2021 we have continued with the development of a module for process flow and run sheet documentation. The aim is to be able to create, edit, stor and share process flows. From the simplest step to long process flows for advanced compnents. The run sheet documentation will be used during the execution of such processes. Here the user will have everything on one page, the recipe, the logbook entries, and their personal notes. During spring of 2022 we will have the Myfab LIMS community to evaluate the work done so far.

In addition, we have continued to update the system with several minor new functions and a modernised communication interface for outside applications (hardware interlocks, homepages and other softwares).

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THE NORDIC NANOLAB NETWORK

Myfab is part of the Nordic Nanolab Network (NNN) which encompass active collaboration by the management, experts, and users of the national nanofabrication research infrastructures in the Nordic countries. NNN is most important for the development of all twelve laboratories involved and is the leading regional network in Europe. During 2021, due to the pandemic, the NNN management team as well as the expert groups did not arrange any physical meeting, arranged severan electronic meetings. Basecamp has continued to serve as an important platform for expert interactions. The Nordic Nanolab User Meeting was re-scheduled to 5–6 Maj 2022, so NNN decided to arrange a topcal webinar to be held during 10–11 May 2021.

NNN Webinar on Maskless Alinger Systems with 200 participants

The Nordic Nanolab Network formed a program committee which made extensive planning and preparations for the webinar, including two "live" rehearsals. The webinar attracted 200 participants. Contributions were presented by expert from several different NNN laboratories. Together with the panel, moderated question and discussion sessions were held. This was the first webinar NNN arranged, and we received very good feedback from the participants, and the organizers gained important experience from the preparation and the execution.

NNUM 2022 program committee in operation from November 2021

The program committee for the Nordic Nanolab User Meeting 2022 (NNUM 2022) started to operate in November 2021. The NNUM 2022 takes place at Chalmers in Gotenburg during 5–6 May 2022.

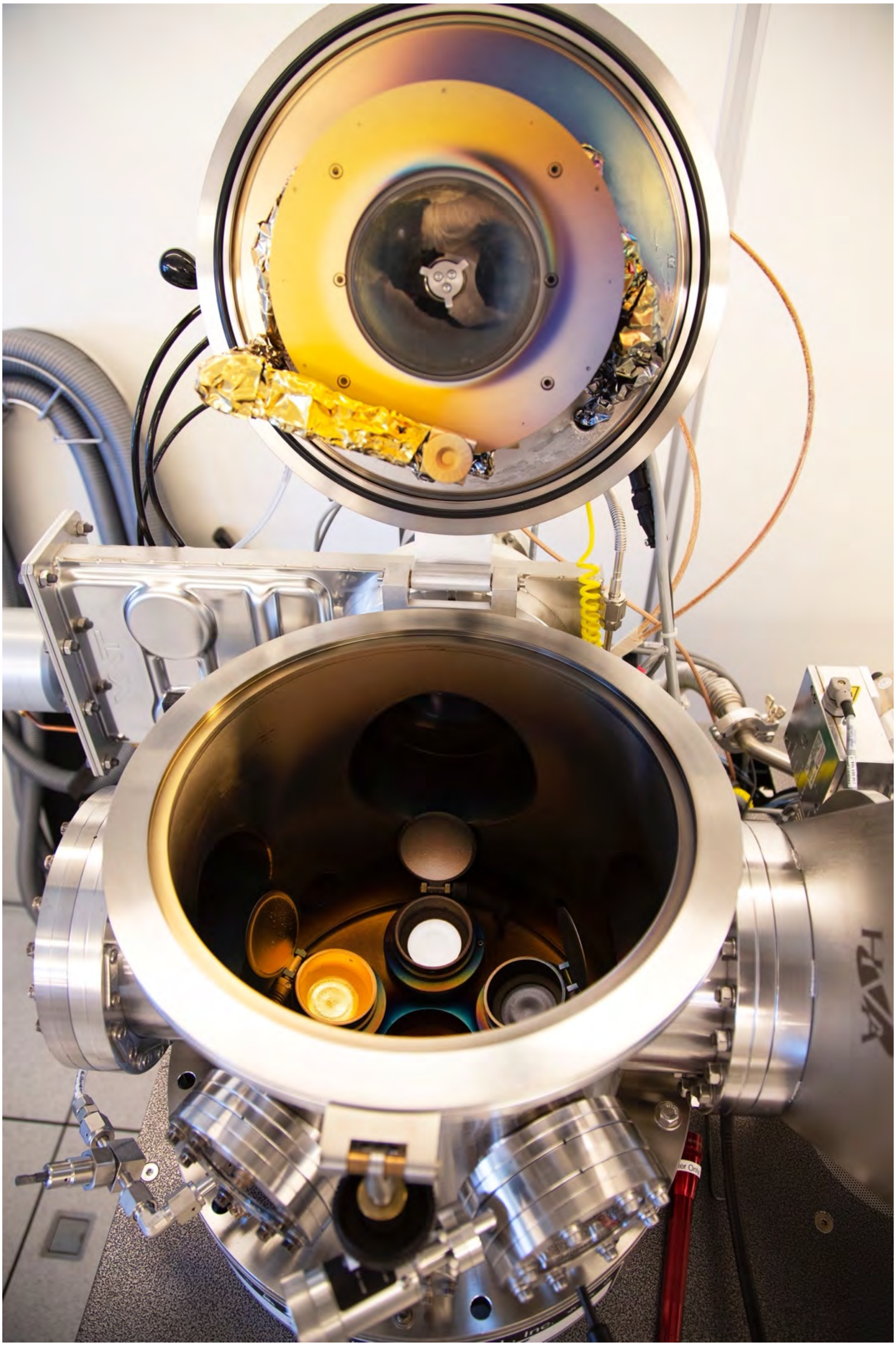
The Nordic Nanolab Expert Network

The Nordic Nanolab Expert Network (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 normally twice per year with lunch-to-lunch meetings. During 2021 most interactions within the NNEN have been carried out through electronic meetings and through the Basecamp platform. The NNEN activities are a very efficient way of promoting staff competence and knowledge transfer / development in the most relevant areas for the res earch infrastructure as a whole and its users.

EURONANOLAB

Myfab is part of EuroNanoLab and was one of the co-founders during spring 2016. Today the EuroNanoLab consortium consists of the national research infrastructures of fourteen countries and one international organisation, with a total of 44 cleanroom laboratories. EuroNanoLab's submitted 2020 a design study to the ESFRI road-map update, but during summer 2021 we were informed that the design study was not accepted, so ENL is not part of the updated ESFRI roadmap. ENL Steering Committee has therefore discussed and which activities that should be prioritized and carried out together in the future. Some on-going activites are expert group collaboration and long-term work on standardization of FAIR Nanofabrication process descriptions.

Furthermore, EuroNanoLab is responsible for the European Nanofabrication Research Infrastructure Symposium (ENRIS), arranged every second year.



NODE ACTIVITIES

Myfab KTH

Myfab KTH consists of two cleanroom facilities. The Electrum Lab in Kista is operated in collaboration with the industrial research institute RISE, and the Albanova Nano Lab in collaboration with Stockholm University. Both laboratories are recognized as "KTH Infrastructures".

Despite the corona-related limitations, the KTH labs are having a steady operational flow, with about the same (as pre-corona) number of users and lab-hours.

All major infrastructures at KTH were during the year evaluated as part of the Research Assessment Exercise. This was be made in form of a written self-evaluation, followed by an on-line discussion with an international evaluation panel. The Myfab laboratories were identified as the two Examples of Success among the KTH infrastructures.

The Electrum Lab board of directors has approved a new strategic plan to handle the most important challenges for the laboratory, including the generation shift of faculty and future research profile, the marketing of the lab resources, re-investment and infrastructure improvement, and the development of Kista from an industrial area into a town. An action plan, based on the strategy has been presented to Rector at KTH. As part of the plan, Per-Erik Hellström is appointed Scientific Director, with task to investigate the conditions for establishing a KTH Semiconductor Research Center.

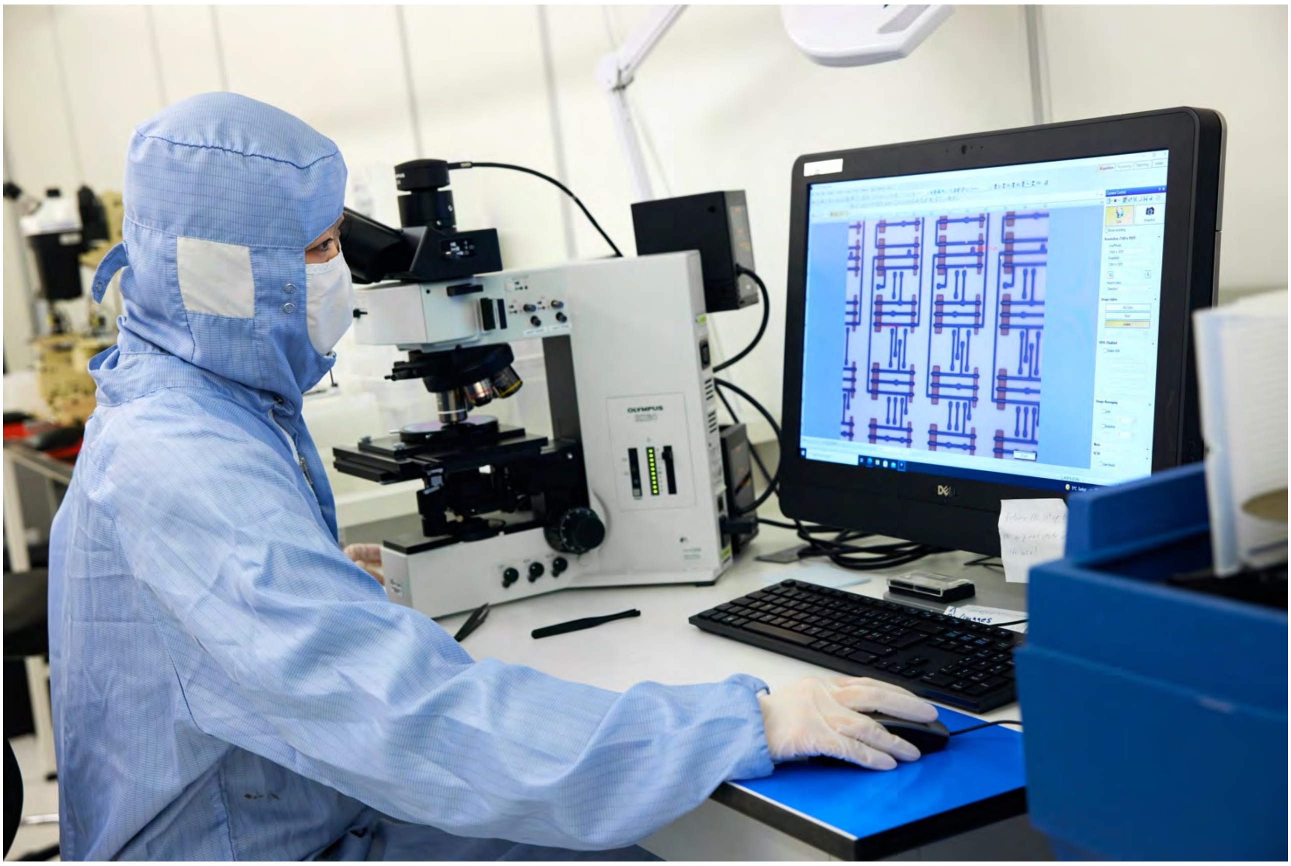
The procurement of tools funded by grants from KTH, Myfab, and other agencies is ongoing.

At Electrum Lab a new Ulvac Enviro 1Xa plasma stripper (funded by user fees), a sheet resistance measurement tool (Myfab funded), a vapor-HF release etcher, and a Disco DAD3241 dicing saw with external cleaning station (financed by RISE) have been installed during the year. The Myfab funded silicon deep etcher and HVPE upgrade are ordered and will arrive in 2022. A relocation of tools and major reconstruction of the cleanroom has been initiated, to clear space for commercial users to rent.

Albanova Nanolab has received a Heidelberg MLA150 mask-less lithography system, and an Oxford Instruments PlamaLab Pro 100 Cobra 300 cryo-etcher (both funded by KTH-WACQT-SU). The Myfab funded AJA UHV evaporator is ordered and expected in summer 2022.

A characterization system QD-PPMS (sponsored by KTH) has been contracted. This will strengthen the interface with the Quantum Technology Hub at Albanova (QTH@KTH-SU) running multiple projects within QT, including a WACQT node in Stockholm. The delivery is planned in the late summer 2022.

In terms of Lab-floor development, the EBL and the Deposition rooms have been re-designed for improved functionality (efficient layout, storage capacity) and user access and experience and the gas distribution system for multiple etchers and deposition systems has been fully re-worked. This will allow a more streamlined and reliable operation, with capacity for future expansion.



Myfab Lund

Myfab Lund is the key resource for all of nanoscience at Lund University with more than 90 tools with an equipment value exceeding 250 MSEK, and with qualified support by highly educated lab personnel. The continued support from Myfab in this period has enabled the specialised services needed from expert staff to service and maintain the equipment inventory; to coordinate external services; to monitor equipment and process stability; to guide and train new users and to develop new information sharing services.

In the period 2020 and 2021, the number of booked hours from academic users was reduced by 35% due to the pandemic, but the income was only reduced by 17%, owing to an increase in commercial usage. Without the dedication of the staff to train users and keep the lab open through the pandemic, the overall performance would have been significantly affected.

During the pandemic, we have received, installed, and completed SAT for our Heidelberg MLA150 Mask-Less Aligner in the ISO 5 area of the clean room. Staff and users have been trained and the team is now preparing to receive a Beneq TFS 200-314 ALD and preparing procurement documentation for an automatic resist / development processing station. A draft technical specification for the high temperature III/V MOVPE is available (funding awarded after Myfab period 5 award) and a pulsed laser deposition (PLD) tool from Myfab's VR appliccaiton in 2021 is in progress. We will be continuing a market survey and developing the technical specification in 2022 to get the inputs of all stakeholders ahead of the open procurement process.

The board of LTH has authorized a procurement of a 1400 m^2 clean room in 2021. Together with ESS and Max IV, the Nano Lab at Science Village (NLSV) will form a third major infrastructure at Brunnshög. The planning for the new clean room also takes a lot of effort and requires time, including systematic work to specify parameters and layout of the new LNL. An in-depth market survey was completed, and a 2-step procurement process of a landlord was initiated, which is expected to be concluded in 2022, after which the detail planning can commence. In advance of the move to Brunnshög, there has been a concerted and successful effort to obtain funding for new and replacement semi-conductor processing and metrology equipment.

We have successfully recruited for 2 positions where staff are retiring, but unfortunately, 2 other employees indicated they will leave in 2022 to pursue other opportunities.

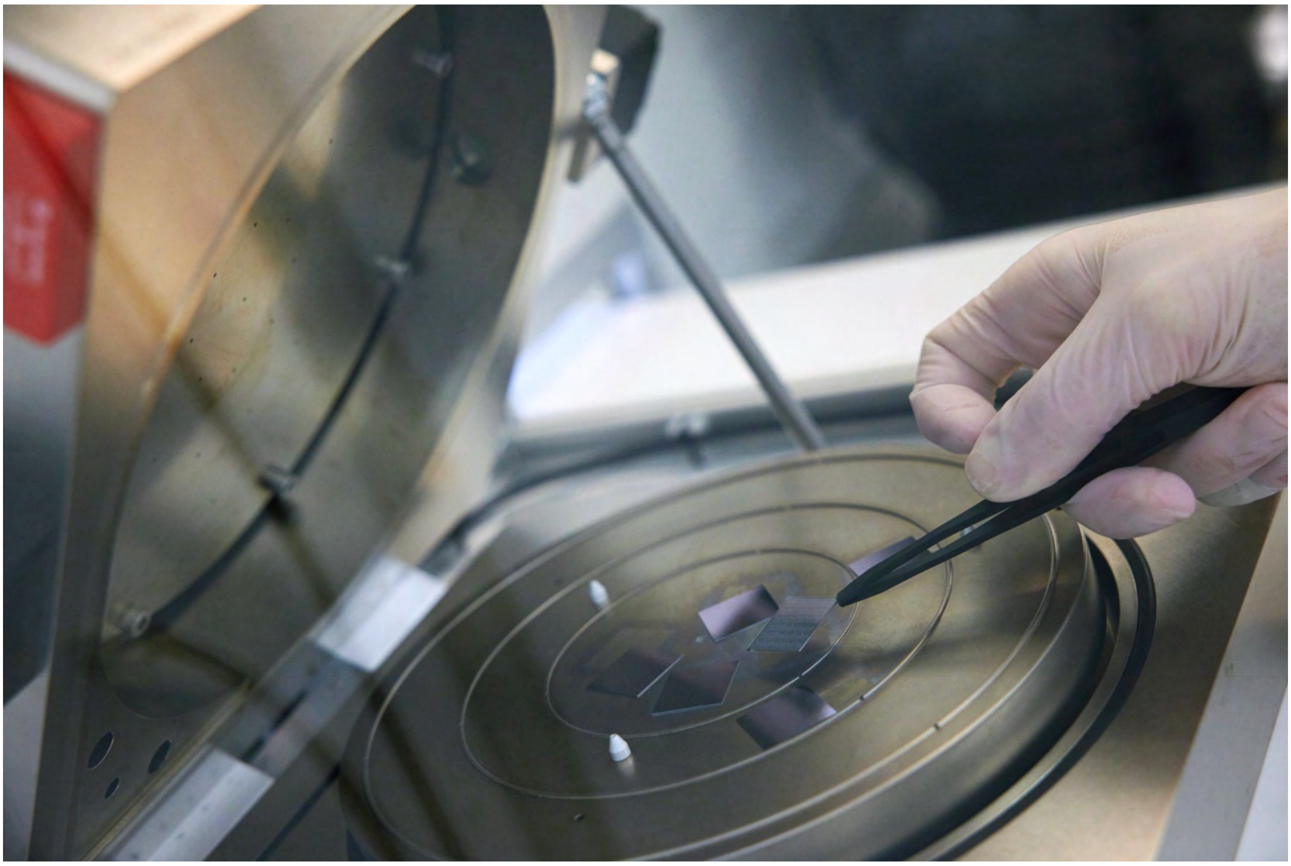
Myfab Uppsala

During 2021 efforts have been made to develop a local investment strategy to prepare for national prioritization at the national Myfab level. Thematic groups, in e.g. lithography and thin film technology, and with the most experienced researchers and engineers in each field, have identified urgent needs and strategic possibilities. The compiled result, including a plan for reinvestments, forms an investment plan that should be revised annually.

The investment funding from the Swedish Research Council have initiated a number of procurements and two deliveries before the end of the year. A 2-photon printer has been fully tested, accepted, and released to our users. Most of the procurements should be concluded this year.

After a final(?) expansion of the Ångström Laboratory rents will be significantly increased. With a 2 000 m^2 cleanroom facility, Myfab Uppsala will be very much affected and measures sould be taken to mitigate these effects. The general solution proposed is to compress the Myfab activities and create some space for individual research groups to rent their own lab premises.

The staff situation is rather stable, but parental and other temporary leaves are difficult to compensate for. With these varying needs for trained and experienced personnel we try to develop some dynamic routines with advanced users and practical coaches working part time for a limited period.



Myfab Chalmers

During 2021 we have at Myfab Chalmers procured five major systems, following our investment plan:

- a plasma enhanced chemical vapour deposition system (Oxford Plasmalab PECVD) for thin films of Silicon Nitride and Silicon Oxide.
- a Silicon deep inductively coupled plasma reactive ion etch (Oxford Estrelas) for Bosch process etching of Silicon
- an ellipsomter for thin film characterisation (Woollam RC2)
- a direct write laser lithography system (Heidelberg MLA 150)
- an automated scanning electron microscope (RAITH Chipscanner 150)

All tools to be commissioned early 2022. These five tools are part of a five-year reinvestment plan for Myfab Chalmers that contain 34 items and a total budget of around 170 MSEK. We have hired two new staff to replace retired staff, one technician and one senior research engineer. We were 22 individuals corresponding to 19 full time equivalents running the cleanroom.

During 2021 we saw a significant increase in the project volumes using the infrastructure. The user fees from both academic and commercial projects reached record high levels and are now well over 50% of the revenue, i.e., the user fees exceed the subsidies from Chalmers and SRC. The commercial user fees where actually slightly higher than the academic. This contributed to our record high profit well needed to finance the expensive reinvestment plan in progress.

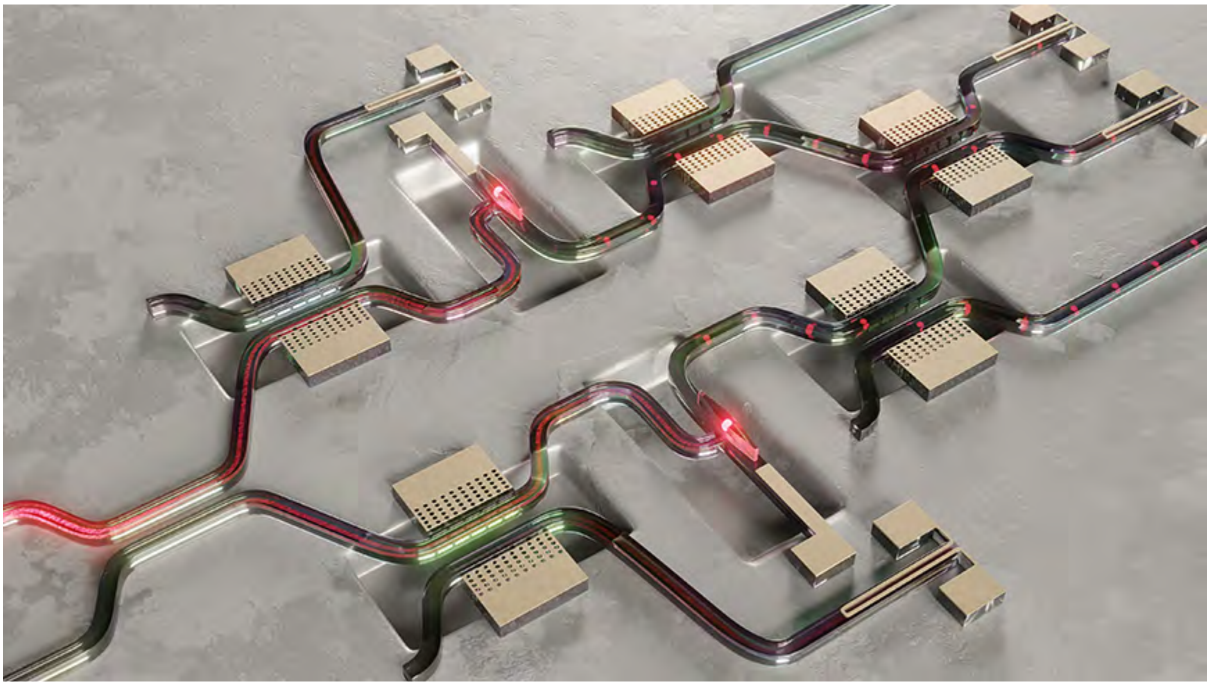
During last year we also introduced our new and in house constructed hardware interlock which prevents user from operating advanced tools without a completed booking in our booking system Myfab LIMS, where we also control who is allowed to book each tool.

SELECTED USER SUCCESS STORIES

Reconfigurable photonics with on-chip single-photon detectors

In a potential boost for quantum computing and communication, a European research collaboration reported a new method of controlling and manipulating single photons without generating heat. The solution makes it possible to integrate optical switches and single-photon detectors in a single chip.

Publishing in Nature Communications, the team reported to have developed an optical switch that is reconfigured with microscopic mechanical movement rather than heat, making the switch compatible with heat-sensitive single-photon detectors. The new method enables control of single photons without the disadvantage of heating up a semiconductor chip and thereby rendering single-photon detectors useless. Usingmicroelectromechanical (MEMS) actuation, the solution enables optical switching and photon detection on a single semiconductor chip while maintaining the cold temperatures required by single-photon detectors.



S. Gyger, J. Zichi, L. Schweickert, A.W. Elshaari, S. Steinhauer, S.F. Covre da Silva, A. Rastelli, V. Zwiller, K.D. Jöns, C. Errando-Herranz, *Nature Communications* **12**, 1408 (2021). *Link;*

Coverage: KTH Press Release, European Commission, phys.org, EurekAlert; Impact factor 14.9

Very large-scale wafer-level integration of 2D materials for smaller and more powerful devices

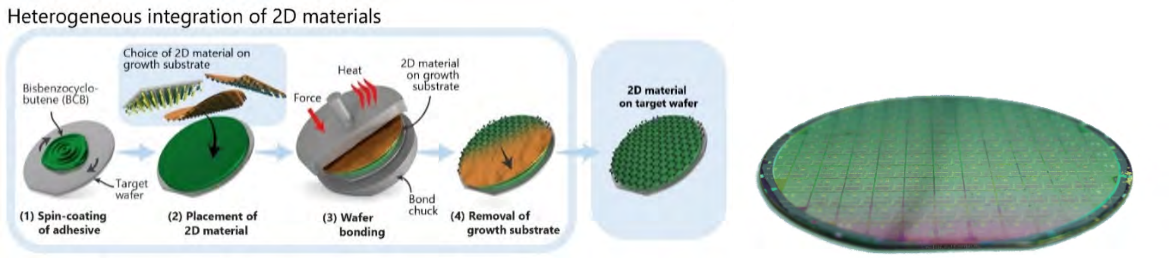


Figure 1: Schematic illustration of heterogeneous integration of 2D materials with semiconductor substrates by adhesive wafer bonding at the back-end of the line.[3]

We have developed a new 2D material integration technology that is based on wafer bonding in a standard semiconductor wafer bonder. This approach fully complies with automated handing procedures for semiconductor wafers, from 100 mm and up to 300 mm diameters. Wafer bonding is a mature process that is customarily used for manufacturing of semiconductor products at extremely high volumes of several 100 million units per year. The utilization of the existing tools in semiconductor fabs and their supply chain is a crucial prerequisite for the price sensitive and risk averse semiconductor industry to incorporate 2D materials in their products. Our integration technology enables integration of 2D materials in the back-end of the fabrication line (BEOL). We have demonstrated the wafer-scale transfer of three different types of 2D materials (graphene, molybdenum disulfide (MoS2), and hexagonal boron nitride (hBN)), that were grown on copper foils and rigid Si substrates. Furthermore, have we stacked 2D materials to heterostructures by two consecutive transfers, and suspended freestanding graphene membranes. In our process, the 2D material is attached to a target wafer by a device-compatible adhesive layer that remains as part of the final device (Figure 1). The bonding process temperature is low and complies with the thermal budget of preprocessed CMOS and microsystem device wafers. This allows to enhance the functionality of established electronics for readout and signal processing by adding the 2D material for a specific target application. We have published our work in Nature Communications [1] and presented the results on several leading conferences in the field of photonics and micro-electro-mechanical systems (MEMS) [2]–[4].

[1] A. Quellmalz *et al.*, “Large-area integration of two-dimensional materials and their heterostructures by wafer bonding,” *Nature Communications*, vol. 12, no. 1, Art. no. 1, Feb. 2021, doi: 10.1038/s41467-021-21136-0.

[2] A. Quellmalz *et al.*, “Wafer-Scale Transfer of Graphene by Adhesive Wafer Bonding,” in *2019 IEEE 32nd International Conference on Micro Electro Mechanical Systems (MEMS)*, Jan. 2019, pp. 257–259. doi: 10.1109/MEMSYS.2019.8870682.

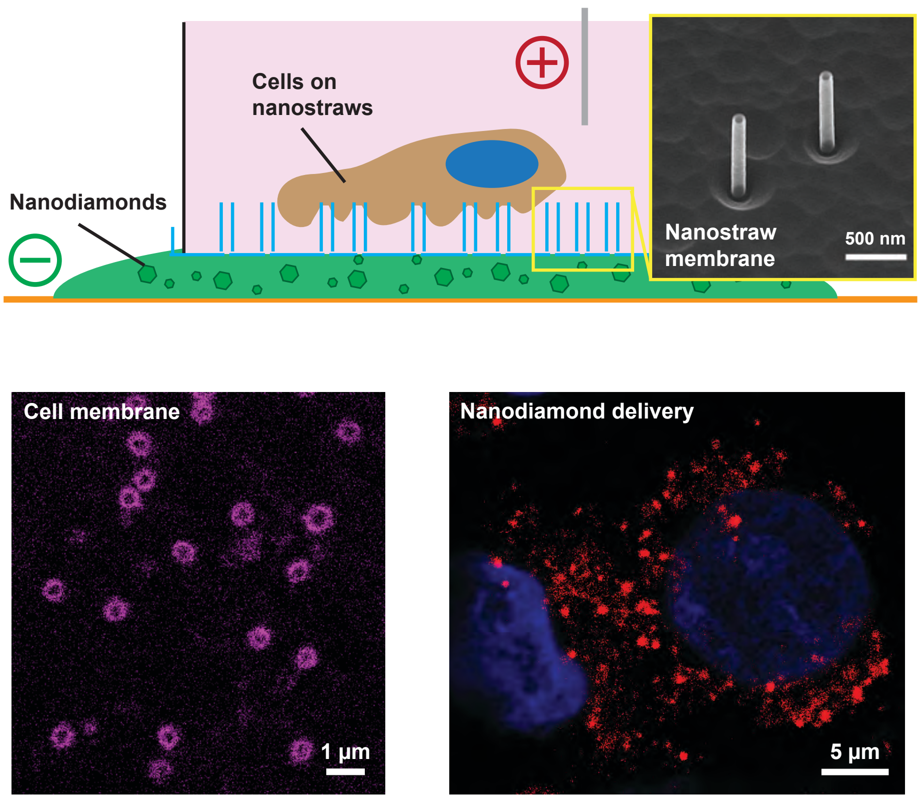
[3] A. Quellmalz *et al.*, “Large-Scale Integration of 2D Material Heterostructures by Adhesive Bonding,” in *2020 IEEE 33rd International Conference on Micro Electro Mechanical Systems (MEMS)*, Jan. 2020, pp. 943–945. doi: 10.1109/MEMS46641.2020.9056203.

[4] A. Quellmalz *et al.*, “Stacking of Two-Dimensional Materials to Large-Area Heterostructures by Wafer Bonding,” in *Conference on Lasers and Electro-Optics (2021), paper SW3F.2*, May 2021, p. SW3F.2. doi: 10.1364/CLEO_SI.2021.SW3F.2.

Nanostraw-Assisted Cellular Injection of Fluorescent Nanodiamonds via Direct Membrane Opening

Fluorescent nanodiamonds are promising for long term monitoring of cells since they exhibit a stable fluorescence and are not toxic. However, it is challenging to deliver fluorescent nanodiamonds to the cell interior, as most of them end up entrapped in cellular compartments, where they cannot interact with the cell biomolecules.

To address that issue, we have used alumina nanotubes, fabricated at the Lund Nano Lab, in combination with mild electrical pulses to inject nanodiamonds in the cell interior with great efficiency. Fluorescence microscopy was used to demonstrate that a greater number of nanodiamonds was located in the cell interior while not being trapped in cellular compartments, as opposed to when using a conventional incubation method to deliver nanodiamonds inside cells.

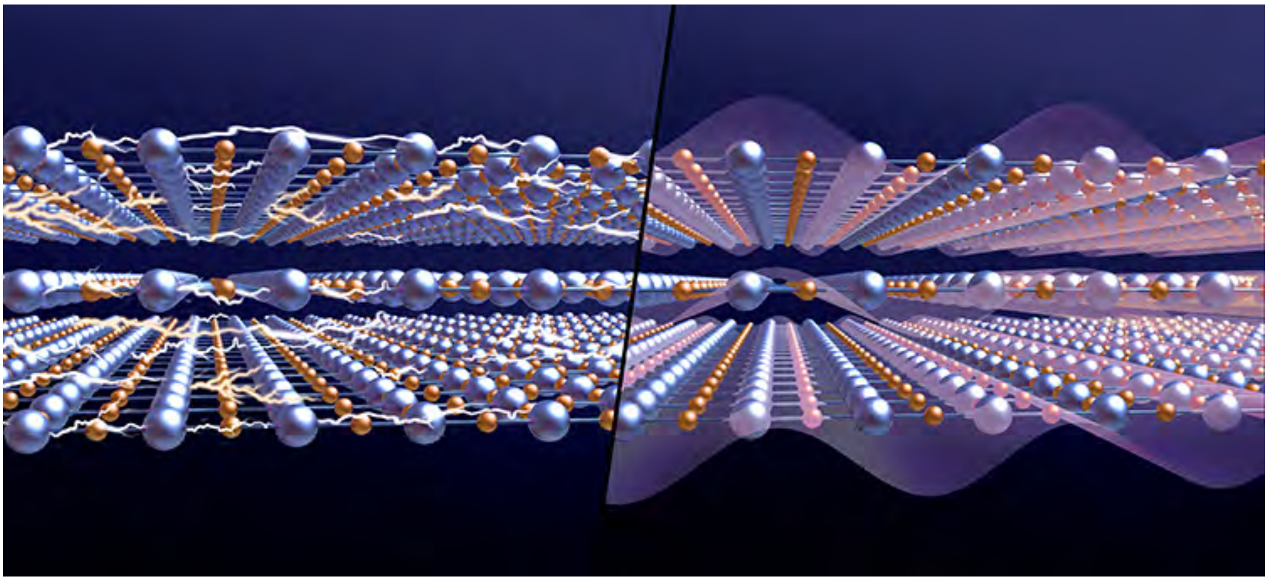


STED microscopy images showed that the cell membrane is opening in a reversible manner on top of the nanostraws upon application of the mild electrical pulses. The results are promising for achieving long term monitoring of living cells.

E. Hebisch, M. Hjort, D. Volpati, C. N. Prinz, *Small 2021*, **17**, 2006421.
Coverage: The Conversation

Making the strange metal state in high temperature superconductors even stranger

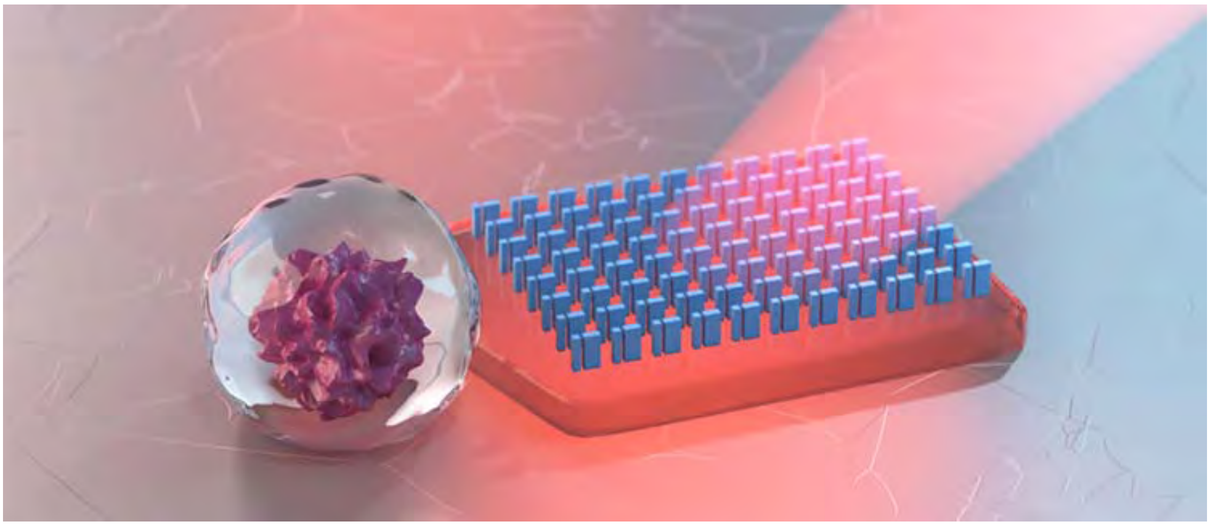
Superconductivity, where an electric current is transported without any losses, holds enormous potential for green technologies. For example, if it could be made to work at high enough temperatures, it could allow for lossless transport of renewable energy over great distances. While standard superconductivity is well understood, several aspects of high temperature superconductivity are still a puzzle to be solved. The newly published research focusses on the least understood property – the so called 'strange metal' state, appearing at temperatures higher than those that allow for superconductivity. The materials really behave in a very unusual way, and it is something of a mystery among researchers.



The strange metal state got its name because its behavior when conducting electricity is, on the face of it, far too simple. In an ordinary metal, lots of different processes affect the electrical resistance – electrons can collide with the atomic lattice, with impurities, or with themselves, and each process has a different temperature dependence. This means that the resulting total resistance becomes a complicated function of the temperature. In sharp contrast, the resistance for strange metals is a linear function of temperature – meaning a straight line from the lowest attainable temperatures up to where the material melts. To explain the counterintuitive properties of the strange metal state, all particles need to be entangled with each other, leading to a soup of electrons in which individual particles cannot be discerned, and which constitutes a radically novel form of matter.

The researchers' work indicates a close connection between the emergence of charge density waves and the breaking of the strange metal state – a potentially vital clue to understand the latter phenomenon, and which might represent one of the most striking evidence of quantum mechanical principles at the macro scale. The results also suggest a promising new avenue of research, using strain control to manipulate quantum materials.

Wahlberg, E., Arpaia, R., Seibold, G., Rossi, M., Fumagalli, R., Trabaldo, E., Brookes, N. B., Braicovich, L., Caprara, S., Gran, U., Ghiringhelli, G., Bauch, T., & Lombardi, F. (2021). Restored strange metal phase through suppression of charge density waves in underdoped YBa2Cu3O7–δ. *Science*, *373*(6562), 1506–1510.



Tiny vehicles powered by nothing but light

Light has an inherent power to move microscopic objects – a property previously used to develop the Nobel prize winning research idea of 'optical tweezers', which use a highly focused laser beam to control and manoeuvre tiny particles with incredible precision.
The researchers manufactured vehicles at a scale of 10 micrometres wide and 1 micrometre thick. The vehicles consisted of a tiny particle, coated with something known as a 'metasurface'. Metasurfaces are ultra-thin arrangements of carefully designed and ordered nanoparticles, tailored to direct light in interesting and unusual ways. They offer fascinating possibilities for use in advanced components for optical applications such as cameras, microscopes and electronic displays. Usually, they tend to be thought of as stationary objects, with their use being seen as the ability to control and affect light. But here, the researchers looked at it the other way around, investigating how the forces resulting from the light's change in momentum could be used to control the meta-surface.

The researchers took their microscopic vehicles, which they termed 'metavehicles', and placed them on the bottom of a water dish, then used a loosely focused laser to direct a plane wave of light onto them. By a purely mechanical process – the heat generated by the light plays no part in the effect – the vehicles could then be moved in a variety of patterns. By adjusting the intensity and polarisation of the light, the researchers succeeding in controlling the vehicles' movement and speed with a high level of precision, navigating them in different directions and complex patterns, such as figures of eight.

The researchers also experimented with using the metavehicles as transporters, to push small particles around the tank. The metavehicles proved capable of transporting objects including a microscopic polystyrene bead and a yeast particle through the water with ease. They even succeeded in pushing a dust particle 15 times the size of the metavehicle itself.

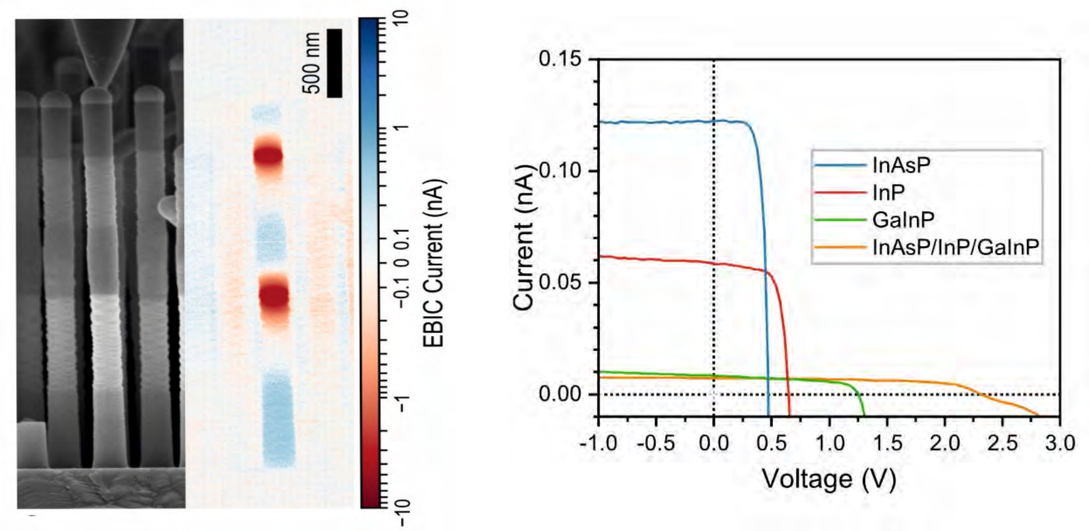
Andrén, D., Baranov, D.G., Jones, S. et al. Microscopic metavehicles powered and steered by embedded optical metasurfaces. Nat. Nanotechnol. 16, 970–974 (2021).

Nanowire based triple junction photovoltaics.

III-V based multi-junction solar cells hold the world record power conversion efficiencies, however, they are too expensive for large area terrestrial applications. Nanowires are being investigated for next-generation solar cell technologies because of the prospect of lowering material costs. So far, nanowire solar cells with promising efficiencies have been developed, although they have been limited to a single junction. In order to further increase the efficiency of nanowire solar cells, multi-junction technology needs to be utilised.

By use of metal organic vapor phase epitaxy and electron beam induced current measurements in a close feedback loop between synthesis and characterisation we developed tandem junction nanowire photovoltaics. This is a major breakthrough which has taken more than ten years of research to achieve, rapidly sped up by investments in new characterisation tools for Myfab Lund. We demonstrate the combination of three sub-cells with optimized band gaps within nanowires of modest length, that have the potential to reach a modelled efficiency of 47 %.

The results represent a milestone in the development of nanowire array solar cells, with more than twice the open-circuit voltage of previously reported nanowire devices. These investigations establish nanowire multi-junction technology photovoltaics, which opens a new possibility for economically, high efficiency, and environmentally sustainable III-V solar cells.



Triple junction nanowire photovoltaics.
Left: Scanning electron image of the nanowire triple junctions contacted in situ by the tungsten probe. In addition, the backside of the sample is used as contact.
Middle: electron beam induced current measurement showing the three junctions, separated by Esaki tunnel diodes which gives a current in the opposite direction to the working pn-junction diodes.
Right: Current-Voltage measurements of InAsP, InP, and GaInP single-junction NWs and a GaInP/InP/InAsP triple-junction NW on a semi-logarithmic scale. As expected, I_{SC} decreases with an increasing band gap, whereas the V_{OC} increases. As the sub-cells are connected in series, the current of the triple-junction NW is limited by the sub-cell with the lowest current. In return, the V_{OC} of the sub-cells are summed up.

Lukas Hrachowina, Yang Chen, Enrique Barrigon, Reine Wallenberg, Magnus T. Borgström, in writing.

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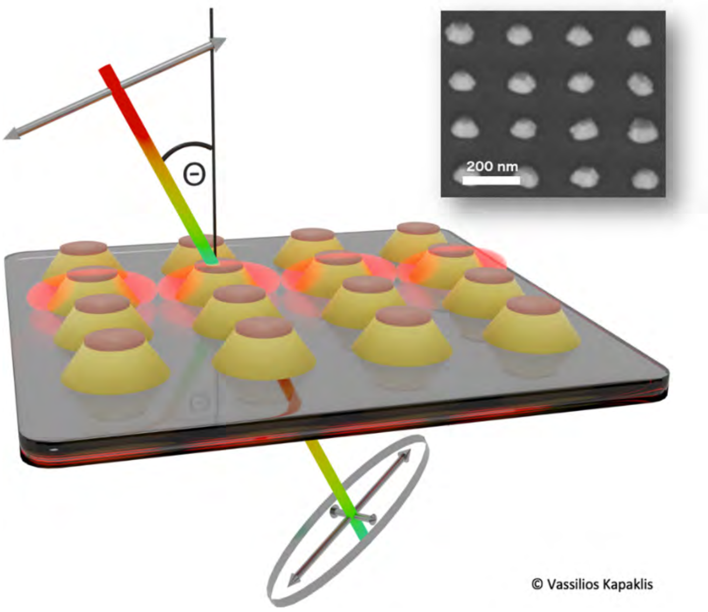
Direction-Sensitive Magnetophotonic Surface Crystals

Researchers at Uppsala University with collaborators from Gothenburg and San Sebastian, Spain, have reported on artificial magnetophotonic surface crystals. These structures are fabricated using state-of-the-art electron beam lithography techniques and are composed of hybrid material architectures, combining magnetic and plasmonic materials. Nanosized Tb18Co82 ferrimagnetic alloy discs (brown color in figure), having strong out-of-plane magnetic anisotropy are placed on top of gold plasmonic nanocone antenna arrays. These are used to design a micrometer-scale magnetophotonic crystal exhibiting abrupt and narrow magneto-optical spectral features that are both magnetic field and light incidence direction controlled. Furthermore, a magnetic modulation of the differential circular transmission through the magnetophotonic crystal, with measurements carried out in zero external magnetic field was demonstrated, exploiting the perpendicular magnetic anisotropy of the magnetic nanoantennas. The integration of such ferrimagnetic alloys with plasmonic nanoantennas offers new exciting platform for highly tunable, ultrafast all-optical switching magneto-photonic devices. This can find further application scope, in the development of devices where light can be efficiently used to switch and read out the magnetization of magnetic nanoelements, paving the way for new ultrafast memory devices.

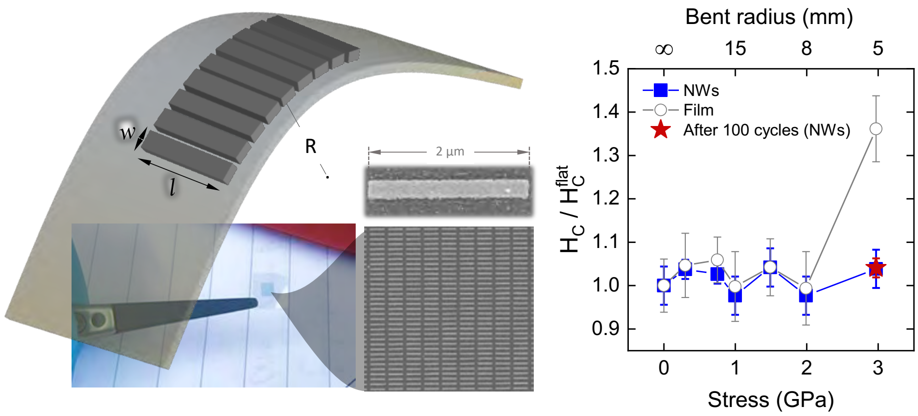


This work has been supported by the Knut and Alice Wallenberg Foundation project "harnessing light and spins through plasmons at the nanoscale" (project no. 2015.0060) and was part of a project which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 737093, "Femtoterabyte."

R. M. Rowan-Robinson, J. Hurst, A. Ciuciulkaite, I.-A. Chioar, M. Pohlit, M. Zapata- Herrera, P. Vavassori, A. Dmitriev, P. M. Oppeneer, and V. Kapaklis, "Direction-Sensitive Magnetophotonic Surface Crystals," Advanced Photonics Research 2, 2100119 (2021), DOI: https://doi.org/10.1002/adpr.202100119.

Ultralow Magnetostrictive Flexible Ferromagnetic Nanowires

Integrating magneto-electric and spintronic sensors into flexible electronics is of utmost importance for the next generation of flexible and wearable technologies. One key challenge here is to engineer nanodevices with stable magneto-elastic properties. Magnetic bulk materials exhibit multidomain magnetic structures, making magnetism very sensitive to strains. Here, highly resilient flexible ferromagnetic Co nanowires are demonstrated for the first time on flexible PEN substrates. The nanowires exhibit an ultralow magnetostrictive constant, resulting in remarkable resilience sustaining extreme bending with high endurance. These stable, flexible magnetic nanowires are expected to impact future applications in flexible spintronics where stable magnetic properties and device performances under bending conditions are needed, for instance, for realizing stable surface mountable and wearable spintronic sensors next-generation flexible steady magnetic switches, spintronics, and magnonic circuits.



Highly resilient mangetic nanowires (NW) on flexible substrates. The plot shows the NW magnetic coercitity in flat $(H_c^{flat})$and bent (HC) condition stay the same till very high number of bending cycles and high levels of stress, compared to thinfilms of the same magnetic material and thick.

G. Muscas, P.E. Jönsson, I.G. Serrano, Ö Vallin and M.V. Kamalakar, "Ultralow Magnetostrictive Flexible Ferromagnetic Nanowires", Nanoscale 13, 6043-6052 (2021).

ECONOMY

Myfab's financial report for 1 January – 31 December 2021, 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 2021.

Income [kSEK]	Myfab Chalmers	Myfab KTH	Myfab Lund	Myfab Uppsala	Myfab all four labs
Faculty grants	32 683	17 250	23 875	8 734	**73 808**
Fees, academic	16 359	12 850	8 921	9 194	**47 324**
Fees companies incl. RISE	18 927	19 600	4 271	3 208	**46 006**
Myfab SRC grant	3 000	3 000	3 000	3 000	**12 000**
Financed depr.	5 260	950	1 147	6 427	**13 784**
Projects SSF, EU		3 440	2 899		**6 3398**
Services		1 660			**1 660**
Income Total	**76 229**	**58 750**	**44 113**	**30 563**	**209 655**
Costs [kSEK]					
Personnel	14 691	15 150	12 794	7 259	**49 894**
Rent premises	17 020	9 710	9 550	9 082	**45 362**
Operation	16 789	22 130	7 663	4 944	**51 526**
Overhead	4 509	7 000	6 555	757	**18 821**
Financed depr.	5 260	950	1 147	6 427	**13 784**
Depreciations	3 385	6 710	6 584	1 707	**18 386**
Costs Total	**61 654**	**61 650**	**44 293**	**30 175**	**197 772**
Result	**14 575**	**-2 900**	**-180**	**387**	**11 882**

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MYFAB STANDARD REPORT 2021 – KEY NUMBERS FROM MYFAB LIMS

	Chalmers	KTH	Lund	Uppsala	2021 Myfab	2020 Myfab	2019 Myfab	2018 Myfab	2017 Myfab
Users with access	433	536	278	451	**1 698**	1632	1648	1658	1611
Active users	194	201	136	280	**811**	782	836	855	804
Female active users	44	55	30	99	**228**	202	210	224	198
Gender balance, active users	23%	27%	22%	35%	**28%**	26%	25%	26%	25%
University active users	160	144	114	242	**660**	646	714	723	669
Institutes active users	2	9	3	2	**16**	17	14	11	11
Commercial active users	32	48	19	36	**135**	119	108	121	124
Companies with own personnel	11	21	8	25	**65**	58	51	56	56
Number of booked hours	60 344	35 139	49 901	25 195	**170 579**	164830	187017	191280	195615
-from universities	53 244	26 093	45 306	23 190	**147 833**	141417	165979	168885	170101
-from institutes	66	2 232	672	68	**3 038**	3198	2233	2323	3220
-from commercial users	7 034	6 813	3 924	1 938	**19 708**	20215	18804	20072	22293
Number of tools	220	274	95	176	**752**	707	738	706	709
Booked tools	158	106	73	83	**420**	402	405	408	404

ANNEXES

Annex A: Myfab Key Numbers 2021
Annex B: Organisation 2021
Annex C: Myfab Accounting of Procuerments 2021
Annex D: Myfab Publications and Doctoral Theses 2021

ANNEX A - MYFAB KEY NUMBERS 2021

Key numbers as specified in Appendix 1 (Bilaga 1) to Myfab's contract (Dnr: 2019-00207)

Infrastrukturens namn: Myfab 5

Diarienummer: 2019-00207
Respondent (namn): Thomas Swahn
Respondent (epost): thomas.swahn@chalmers.se
Respondent (telefon): 0730-744676
Avser år: 2021

Katergorier av nyckeltal
1 Anställda (enskilda individer (eller FTE))
2 Projekt (fakturerade)
3 Användare (enskilda individer)
4 Kvantitet av användning [timmar]
5 Output

1	Anställda vid infrastrukturen	
1.1	*Enskilda individer*	
	Totalt	
	Ledning (labchefer ingår)	5
	Vid Myfab Chalmers	22
	Vid Myfab KTH	23
	Vid Myfab Lund	16
	Vid Myfab Uppsala	14
1.2	*FTE*	
	Totalt	
	Ledning	
	Vid Myfab Chalmers	19
	Vid Myfab KTH	18,4
	Vid Myfab Lund	13,9
	Vid Myfab Uppsala	9,8

		a. Alla projekt			b. Typ av hemvist för alla projekt						c. Typ av akademisk hemvist för projekt (endast akademiska hemvister)			
					Akademisk			Kommersiell	Offentlig	Övriga				
2	Projekt	Totalt	Män	Kvinnor	Totalt	Män	Kvinnor	Totalt	Totalt	Totalt	Värdorganisation	Inom konsortiet, ej värd	Annat svenskt lärosäte	Internationell
2.2	*Genomförda projekt*													
	Totalt													
	Vid Myfab Chalmers	151	140	11	125	114	11	26	2		115	5	6	4
	Vid Myfab KTH	146	131	15	107	97	10	31	8	0	98	4	5	0
	Vid Myfab Lund	81	70	11	64	55	11	15	0	0				
	Vid Myfab Uppsala	116	41	75	88	31	57	25	3	0	82	5	1	0

		d. Alla användare			e. Typ av hemvist för alla användare						f. Typ av akademisk hemvist för användare (endast akademiska hemvister)			
					Akademisk			Kommersiell	Offentlig	Övriga				
3	Användare	Totalt	Män	Kvinnor	Totalt	Män	Kvinnor	Totalt	Totalt	Totalt	Värdorganisation	Inom konsortiet, ej värd	Annat svenskt lärosäte	Internationell
3.2	*Genomförda projekt*													
	Totalt													
	Vid Myfab Chalmers	197	156	41	162	127	35	34	1		147		14	1
	Vid Myfab KTH	201	146	55	144	106	38	48	9		128	9	7	
	Vid Myfab Lund	136	106	30	114	25	89	19	9					
	Vid Myfab Uppsala	280	181	99	242	157	85	36	2		234	7	1	

		g. Total kvantitet per typ av tillgång till		h. Kvantitet av tillgång för akademiska projekt		
		Alla användare		Fysisk tillgång till infrastruktur		
4	Typ och kvantitet av tillgång	Fysisk [antal anv.]	timmar	Totalt (timmar)	Män (andel, %)	Kvinnor (andel, %)
4.1	*Användning under året*					
	Totalt					
	Vid Myfab Chalmers	197	60344	53251	78%	22%
	Vid Myfab KTH	201	35139	26093	73%	27%
	Vid Myfab Lund	136	49901	45306	78%	22%
	Vid Myfab Uppsala	280	25195	23190	65%	35%

5	Output		
5.1	Publikationer	Bifoga lista enl specifikation	
5.2	Antal examinerade doktorer	Som haft en väsentlig verksamhet i Myfab	

ANNEX B – ORGANISATION 2021

General Assembly members (Stämma)

Chairman:
Lars Börjesson, Senior Advisor to the President, Chalmers
Annika Stensson Trigell, Vice Rector KTH
Stacey Ristinmaa Sörensen, Vice Rector Lund University
Johan Tysk, Vice Rector Uppsala University

Steering Group members

Chairman:
Mikael Östling, Deputy President KTH
Marcus Aldén, Professor, Lund University
Anne Borg, Rector NTNU Trondheim
Mikael Jonsson, Professor, Uppsala University
Ellen Moons, Professor, Karlstad University
Anna Stenstam, CEO CR Competence, Lund
Henrik Thunman, Professor Chalmers

Operational management

Director:
Thomas Swahn, Docent

Laboratory Managers:
Myfab Chalmers: Peter Modh, Ph.D.
Myfab KTH: Nils Nordell, PhD.
Myfab Lund: Luke Hankin, PhD.
Myfab Uppsala: Stefan Nygren, PhD.

Support systems and project manager:
Cristina Andersson, Ph.D.

ANNEX C – MYFAB ACCOUNTING OF PROCUREMEN 2021

Accounting of procurements during 2021.

Some of the procurements financed by the grant from the Swedish Research Council Dnr. 2019-00207 – Myfab 5 were finalized during 2021 and are reported using the template: "Mall för redovisning upphandling samt för slutredovisning av vetenskaplig utrustning.xlsx".

	Mall för redovisning av upphandling samt för slutredovisning av vetenskaplig utrustning/inköpt tjänst till Vetenskapsrådet				
	Huvudsökandes namn	Thomas Swahn			
	Telefon och e-post	0730-744676, thomas.swahn@chalmers.se			
	Medelsförvaltare	Chalmers			
	VR Diarienummer	2019-00297 – Myfab 5			
		Pris	**Leverantör**	**Förklarande text** (Ytterliggare förklaring om det inte framgår av kolumn B)	
	Utrustning (här redovisas vad varje faktura avser. Om flera fristående delar upphandlats redovisas de under egna rubriker)				
1	***Sheet Resistance & Resistivity measuring system***				
1.1	*60% after delivery and instalation*	*216 540 kr*	*MDC Materials Development corp.*	*CMT-SR2000N Measurement system*	
1.2	*40% after final approval*	*144 360 kr*	*MDC Materials Development corp.*	*CMT-SR2000N Measurement system*	
2	***2-photon printer***				
2.1	*UpNano NanoOne*	*3 652 060 kr*	*UpNano Gmbh*	*High-resolution 3D printer for polymeric microparts.*	
2.2	*Komponent (enl. faktura)*	*x*	*D*		
3	***Chip scanner***				
3.1	*RAITH Chip Scanner 150*	*3 272 484 kr*	*RAITH Nanofabrication*	*A CD SEM with an interferomtric stage for accurate and automated imaging for process development and e-beam lithography feedback.*	
5	**Andra kostnader** (här redovisas exempelvis kostnader i samband med installation eller transporter)				
5.1	*Kostnad (enl. faktura)*	*x*	*G*	*Text*	
5.2	*Kostnad (enl. faktura)*	*x*	*G*	*Text*	
5.3	*Kostnad (enl. faktura)*	*x*	*H*	*Text*	
6	**Lönekostnader** (endast för dem som konstruerar/modifierar utrustning själv och att det har angetts i ansökan. Kostnader styrks med utdrag ur högskolans ekonomisystem)		Här redovisas vem som arbetat med att konstruera/modifiera instrumentet	Här kan redovisas vad som respektive person arbetat med om det inte framgår ur kolumn B	**Tid** (Här redovisas antal timmar som respektive person arbetat)
6.1	*kostnad för vad*	*x*	*N.N.*	*Text*	*No timmar*
6.2	*kostnad för vad*	*x*	*N.N.*	*Text*	*No timmar*
	SUMMA	*Summa(x)*			

Sifforna i vänsterkolumnen skrivs på fakturakopiorna som bifogas redovisningen av upphandlingen.
Den texten som är kursiverad bör bytas ut mot vad kostnaden avser. Ta bort/lägg till kursiverade rader efter behov.
Du kan antingen mejla rapporten till infrastruktur@vr.se – med elektroniska/skannade signaturer - eller skicka den med vanlig post till Charlotta. Bifoga fakturakopior till rapporten.

Charlotta Bergvall
Vetenskapsrådet
Box 1035, 101 38 Stockholm

kontaktperson för redovisningen:
Telefon och e-postadress:

Redovisningen ska undertecknas av en behörig företrädare för medelsförvaltaren.

Medelsförvaltare Namnförtydligande

166993 46

MDC Materials Development (Corp) S.A.
Grand Rue 36
1297 Founex
Switzerland

Tel: 0041 22 782 65 38
Fax: 0041 22 782 65 39
Info@mdc-europe .com

Invoice number :	**2407/4848-21**
Direct Procurement of Sheet Resistance mapper	
	J-2021-1095
Your REF :	PEREH KTHEECS
VAT #	**SE202100305401**

PEREH KTHEECS
KTH Royal Institute of Technologys
2021003054
Brinellvagen 8
100 44
Stockholm
Sweden

Date

Date	13th July 2021		
Prix	SEK	**Tarif douanier**	9030820000
		Origin	Korea
Paiement	60% ot the price 360900 SEK due after delivery and installation		
Banque	UBS - Rue du Rhône 8 - 1204 Genève/Suisse **IBAN: CH29 0024 0240 3758 6260 T** **SWIFT/BIC code: UBSWCHZH80A** **Merci d'indiquer notre numéro de référence: 2407/4848-21**		

Pos.	Qty	Description	Model	P.U. Unit	Sek	Total
		60% ot the price 360900 SEK due after delivery and installation	CMT-SR2000N	216 540,00	SEK	216 540,00
1	1	CMT-SR2000N Sheet Resistance & Resistivity Measuring System Range: 1m Ohms/sq- 2M Ohms/sq Measurement Time: Approx. 2+- sec/point Electronic Accuracy 0,5% (precision Resistor) Measurement Dimension: up to 8" (200mm) wafer Operation & data Analisys Software: Contour/ 3D Mapping & Printing User Manual				-
2	1	Jandel Four Point Probe				
			Sub-total		**SEK**	216 540,00
			+ TVA 0%		**SEK**	-
			Total		**SEK**	**216 540,00**

MDC Materials Development Corp. SA

Conditions de Vente:
MDC se réserve le droit d'appliquer un intérêt de 1.5% par mois sur tous les soldes impayés.
Si un recouvrement est nécessaire, l'acheteur devra payer tous les frais engendrés.
Les équipements restent la propriété de MDC jusqu'au réglement total de la facture.
Title to this equipment shall remain with MDC until invoice is paid.

Verifikationsnummer: 80045136.000000 **Fakturanummer:** 2407/4848-21 **Lev.nr:** 10099346 **Fakturadatum:** 13.07.2021

Konteringsinformation

Trans.typ	Valuta	Valutabelopp	Belopp	Konto	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5	Dim 6	Dim 7	MK
	SEK	216540.00	216540.00	1298	JCB	6854		E			3	0
	SEK	-216540.00	-216540.00	2585	JAX			E				0

16099346

MDC Materials Development (Corp) S.A.
Grand Rue 36
1297 Founex
Switzerland

Tel: 0041 22 782 65 38
Fax: 0041 22 782 65 39
Info@mdc-europe .com

Invoice number :	**2410/4848-21**
Direct Procurement of Sheet Resistance mapper	
	J-2021-1095
Your REF :	**PEREH KTHEECS**
VAT #	**SE202100305401**

PEREH KTHEECS
KTH Royal Institute of Technologys
2021003054
Brinellvagen 8
100 44
Stockholm
Sweden

Date

Date	13th July 2021		
Prix	SEK	**Tarif douanier**	9030820000
		Origin	Korea
Paiement	40% ot the price 360900 SEK due after the Acceptance test and final approval by KTH		
Banque	UBS - Rue du Rhône 8 - 1204 Genève/Suisse **IBAN: CH29 0024 0240 3758 6260 T** **SWIFT/BIC code: UBSWCHZH80A** **Merci d'indiquer notre numéro de référence: 2410/4848-21**		

			Model	P.U.		Total
Pos.	**Qty**	**Description**	**Model**	**Unit**	**Sek**	**Total**
		40% ot the price 360900 SEK due after acceptance test and final approval by KTH	CMT-SR2000N	144 360,00	SEK	144 360,00
1	1	CMT-SR2000N Sheet Resistance & Resistivity Measuring System Range: 1m Ohms/sq- 2M Ohms/sq Measurement Time: Approx. 2+- sec/point Electronic Accuracy 0,5% (precision Resistor) Measurement Dimension: up to 8" (200mm) wafer Operation & data Analisys Software: Contour/ 3D Mapping & Printing User Manual				-
2	1	Jandel Four Point Probe				
			Sub-total		**SEK**	144 360,00
			+ TVA 0%		**SEK**	-
			Total		**SEK**	**144 360,00**

MDC Materials Development Corp. SA

Conditions de Vente:
MDC se réserve le droit d'appliquer un intérêt de 1.5% par mois sur tous les soldes impayés.
Si un recouvrement est nécessaire, l'acheteur devra payer tous les frais engendrés.
Les équipements restent la propriété de MDC jusqu'au réglement total de la facture.
Title to this equipment shall remain with MDC until invoice is paid.

Verifikationsnummer: 80045128.000000 **Fakturanummer:** 2410/4848-21 **Lev.nr:** 10099346 **Fakturadatum:** 13.07.2021

Konteringsinformation

Trans.typ	Valuta	Valutabelopp	Belopp	Konto	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5	Dim 6	Dim 7	MK
	SEK	144360.00	144360.00	1298	JCB	6854		E			3	0
	SEK	-144360.00	-144360.00	2585	JAX			E				0

UpNano GmbH, Modecenterstrasse 22/D36, 1030 Vienna, Austria

Uppsala University

Department of Materials Science and Engineering
Box 35
751 03 Uppsala
Sweden

Ref: 120MSL – Stefan Nygren

VAT: SE202100293201

Leverantörsid	Referenskod	Valutakod
U[redacted]	120MSL	SEK

Order number: 2021M009
Agreement number Uppsala University: UH2020/39
Vienna, 1st September 2021

INVOICE 2021/M009/A030

Pos	Product description	Price in SEK *per pcs. excl. VAT*	pcs	Price in SEK *excl. VAT*
1	**NanoOne 250** order number: 5034-250-1	*3,652,060.00*	1	3,652,060.00
			Sub total	3,652,060.00
			VAT	0,00
			Total	**3,652,060.00**

We kindly ask you to transfer the invoice according to our agreed terms of payment, within 30 days from date of invoice (until 1st October 2021) without deductions (SEK 3,652,060.00).

For further questions I am still at your disposal at any time
With kind regards

Denise Hirner, MSc
Head of Marketing and Business Development | Founder

Bank account Erste Bank, Am Belvedere 1, 1100 Wien
IBAN: AT76 2011 1839 5035 9100, BIC: GIBAATWWXXX
UID ATU 74021658 **CEO** Dr. Bernhard Küenburg
Reg. office of the association Vienna FN 498407 b
e-mail office@upnano.at **web** www.upnano.at

ANNEX D – MYFAB PUBLICATIONS AND DOCTORAL THESES 2021

Peer-reviewed publication lists Doctoral Theses from

Myfab Chalmers:	150 publications, 15 doctoral these
Myfab KTH:	124 publications, 12 doctoral theses
Myfab Lund:	199 publications, 11 doctoral theses
Myfab Uppsala:	272 publications, 23 doctoral theses

In total 745 peer-reviewed publications and 61 doctoral theses during 2021.

Myfab KTH Peer Reviewed Journal and Conference Papers

1. Agha Karimi, Armin (2021). Internal Variability Role on Estimating Sea Level Acceleration in Fremantle Tide Gauge Station. FRONTIERS IN EARTH SCIENCE 2296-6463, 9, -, ISI: 000667660000001

2. Agha Karimi, Armin; Bagherbandi, Mohammad; Horemuz, Milan (2021). Multidecadal Sea Level Variability in the Baltic Sea and Its Impact on Acceleration Estimations. Frontiers in Marine Science, 8, -, ISI: 000693846900001

3. Akan, Rabia; Vogt, Ulrich (2021). Optimization of Metal-Assisted Chemical Etching for Deep Silicon Nanostructures. Nanomaterials, 11, -, ISI: 000724502400001

4. Albertsson, Dagur Ingi; Zahedinejad, Mohammad; Houshang, Afshin; Khymyn, Roman; Akerman, Johan; Rusu, Ana (2021). Ultrafast Ising Machines using spin torque nano-oscillators. Applied Physics Letters 0003-6951, 118, -, ISI: 000629823900001

5. Bai, Xuan; Liu, Wenjuan; Xu, Laijun; Ye, Qing; Zhou, Huasi; Berg, Camilla; Yuan, He; Li, Jiyao; Xia, Wei (2021). Sequential macrophage transition facilitates endogenous bone regeneration induced by Zn-doped porous microcrystalline bioactive glass. Journal of materials chemistry. B 2050-750X, 9, 2885-2898, ISI: 000635763800009

6. Basso Basset, F.; Salusti, F.; Schweickert, Lucas; Rota, M. B.; Tedeschi, D.; Covre da Silva, S. F.; Roccia, E.; Zwiller, Val; Jöns, Klaus D.; Rastelli, A.; Trotta, R. (2021). Quantum teleportation with imperfect quantum dots. NPJ QUANTUM INFORMATION 2056-6387, 7, -, ISI: 000612933500003

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