Myfab Annual Report 2014

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

myfab

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MYFAB SUMMARY

Myfab is the Swedish national research infrastructure for cleanroom-based microtechnology, nanoscience, and characterisation, funded by the Swedish Research Council, and the three participating universities[1]. Myfab is an integrated open-access infrastructure serving about 660 active users and 80 companies[2].

Vision

Myfab is the first choice, world-class infrastructure for micro- and nanoscale fabrication and characterization, enabling researchers and innovators to solve the grand challenges of the future.

Mission

Myfab provides cleanroom-based resources for microtechnology and nanoscience, supporting researchers and innovators in achieving world-class results and developing products for the needs of society.

Myfab's ambition is to offer the best available tools and support to its users in a timely manner. Since nanoscience and nanotechnology is one of the most important fields for research and development, and since the field develops very rapidly, it is of the utmost importance for the competitiveness of Swedish researchers and innovators that the development of Myfab continues.

[1] *The three universities are Chalmers University of Technology in Gothenburg, KTH Royal Institute of Technology in Stockholm and Uppsala University. The university and external funding consists of base support from the universities and academic and external user fees.*

[2] *From Myfab LIMS data for year 2014. Active users are users who perform activities themselves within the cleanrooms. Such users are typically part of user groups in the near environment of Myfab: in measurement laboratories or in companies, continuing the work by performing analyses, integration tasks etc.*

Common values

Sharing

We share common resources, knowledge and opportunities. We pass our knowledge on to others to enable continuous improvement.

Supporting

We have an open and generous environment with a framework for supporting each other to constantly enhance our results.

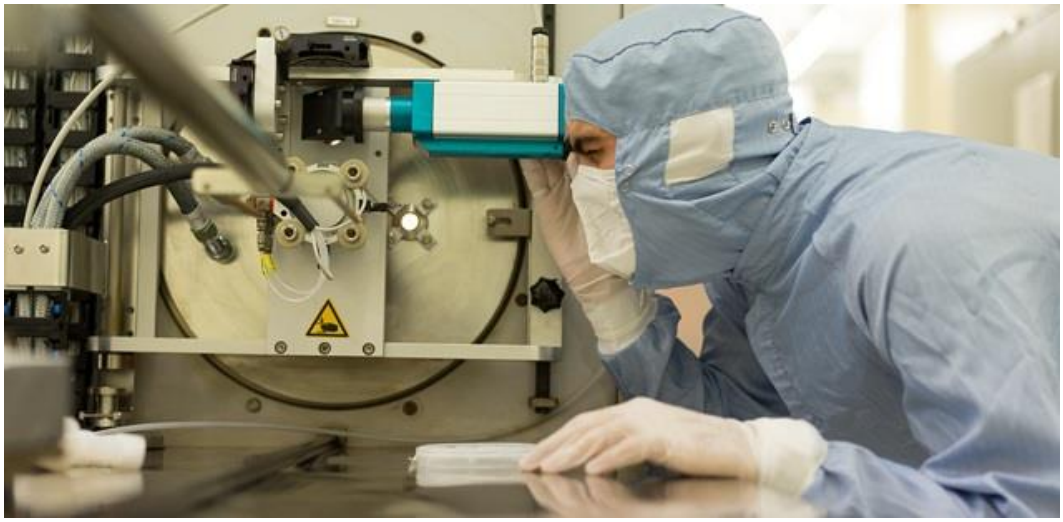
Taking responsibility

We take individual responsibility for everything we do and we act for quality.

Myfab – the focal point of the nation's efforts[3]

Being Sweden's national research infrastructure for microtechnology and nanoscience, Myfab attracts the vast majority of Sweden's nanotechnology researchers and entrepreneurs within its field. Compared to the first year when Myfab LIMS was introduced at all Myfab laboratories (2008), the number of active users has increased from 493 to 664 (+34.7 %) in 2014. This is an "all time high" for the seventh year in row. In 2014, 555 (83.6 %) users come from academia and 109 (16.4 %) were commercial users from either industry or institute. Myfab annually serves about 80 companies. New and potentially returning users, with no previous experience from Myfab, are invited to apply for funding for their first project through *Myfab Access*.

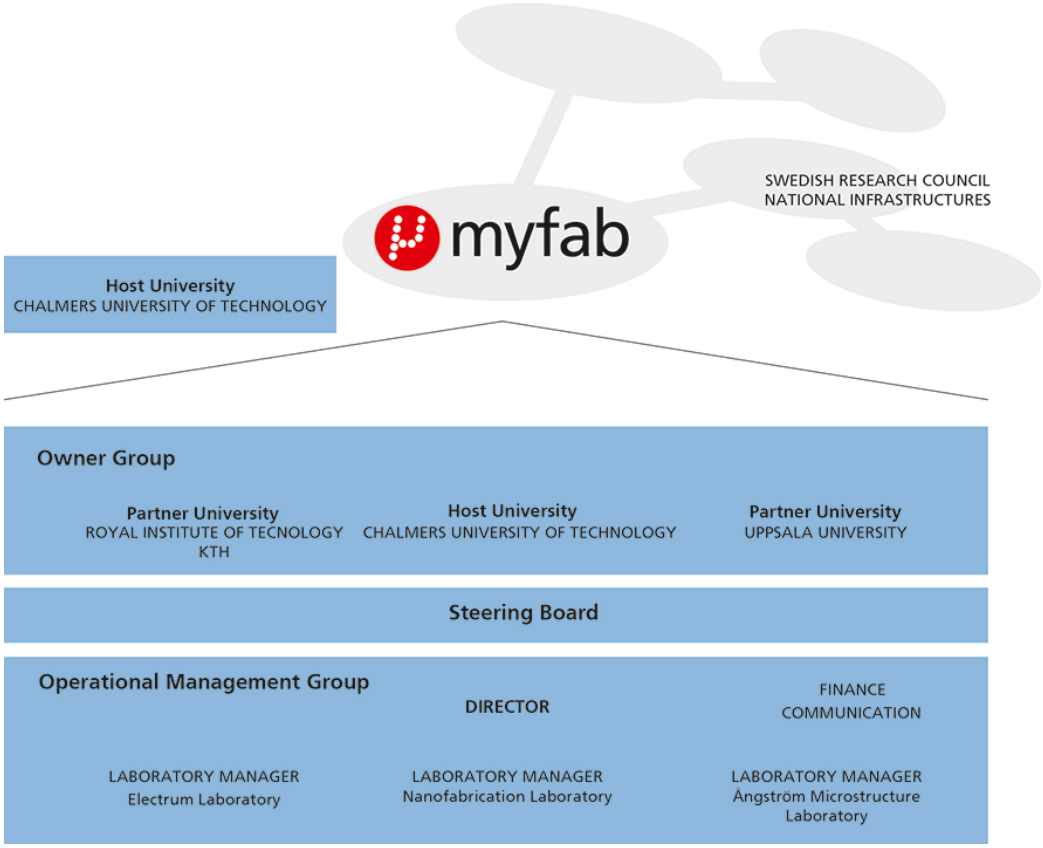
During the last years, Myfab has had a close collaboration with Lund University. Since a few years, a process aiming to fully integrate Lund NanoLab (LNL) into Myfab has matured into a decision to apply for funding together for Myfab's fourth period of operation, starting 1 January 2016. LNL uses Myfab LIMS, and reports 147 active users during 2014. Adding this number to Myfab's 664 active users gives altogether 811 active users, which indicates the size of the future Myfab.



[3] *The Swedish Research Council: Interim Evaluation of 11 National Research Infrastructures – 2012. Vetenskapsrådets lilla rapportserie 10:2012, ISBN 978-91-7307-219-9.*

Myfab LIMS statistics for 2014
We have generated an annual report from Myfab LIMS, using the standard format. The report is attached as a supplement to this report. Compared to 2013, the total usage is roughly constant: we see a small increase of the number of active users, from 647 to 664, at the same time as the total number of booked tool hours decreases slightly from 131 923 to 123 156.

MANAGEMENT



Myfab's owner group

Myfab is a joint undertaking of three Myfab universities: Chalmers, KTH Royal Institute of Technology and Uppsala University. Each Myfab University owns the local cleanroom laboratory. Myfab's owner group is therefore formed to address matters where Myfab's undertakings and the University's strategy overlap. The owner group during 2014 consists of: Prof. Dag Winkler, MC2, Chalmers (representing the host university), Prof. Mikael Jonsson, Uppsala University, and Prof. Carl-Mikael Zetterling, KTH. The participating universities have agreed to collaborate according to the Consortium Agreement, and to the Main Contract between the host university (Chalmers) and the Swedish Research Council (SRC).

Myfab's steering group

Myfab's steering group, appointed by Chalmers University of Technology (Chalmers) for the period 2013-01-01 – 2014-12-31, consisted of seven members: Hans Hentzell, CEO Swedish ICT (chairman), Gunilla Bökmark (CEO Sahlgrenska Science Park), Ludvig Edman (Prof.

Physics, Umeå University), Håkan Engqvist (Prof. Physics, Uppsala University), Per-Erik Hellström (Assoc. professor Solid-State Electronics, KTH), Susanne Holmgren (Prof. Emerita Zoophysiology, University of Gothenburg), nominated by SRC, Nils Mårtensson (Prof. Physics, Uppsala University), nominated by SRC. The steering group is in charge of Myfab's activities during the current period of operation 2010 – 2014[4].

Steering group meetings

Myfab's steering group have had four meetings during 2014, in Gothenburg on 21 January, in Uppsala on 14 April, in Gothenburg on 16 September and a telephone meeting on 12 December. The meeting on 21 January focused on discussions on Myfab's application for the next period of operation, and was a joint meeting with Myfab's owner group, the International Science and Technology Advisory Board (ISTAB), and the operational management. Specially invited were representatives from Lund University. At the time of the meeting, it was not known that Myfab would receive funding during 2015, without application, at the 2014-level.

Operational management

Myfab's operation is managed by the Director Thomas Swahn in collaboration with the laboratory managers Peter Modh (Chalmers), Stefan Nygren (Uppsala University) and Nils Nordell (KTH).

Christina Caesar served as communications officer for Myfab during the first half of 2014, and Michael Nystås together with Cristina Andersson, has supported Myfab in communication and project managerial tasks during the second half of 2014.

Project managers and representatives from Myfab's owner group are invited to participate in some meetings, projects and workshops.

Myfab's International Science and Technology Advisory Board - ISTAB

Myfab's International Science and Technology Advisory Board (ISTAB) consists of two members: Prof. William Stanchina (University of Pittsburgh, PA, USA) and Prof. Alain Cappy (IEMN, University Lille1/RENATEC, France). On 21 January ISTAB participated in a board meeting in Gothenburg.

Myfab LIMS

During 2014 we continued to develop our booking and management system Myfab LIMS. We launched two releases and a couple of minor patches and in total worked with around 80 features and fixes during the year. A separate Myfab-LIMS database has been installed to display all tools within the Ångström Laboratory that are not part of Myfab-MSL. This should serve to make the overall resources more visible and also to stimulate collaboration and shared usage. Although we did not arrange a Myfab LIMS User meeting in 2014 we have had several

[4] *On 10 February 2014, the SRC informed Myfab and 10 other national research infrastructures that they will extend the financing period through 2015, at the budget level of 2014. The decision was motivated by the fact that the SRC will improve the support model for large national research infrastructures, and the new model will be introduced by 1 January 2016.*

discussions about the development in the Nordic Nanolab Network where all nodes except Danchip run Myfab LIMS.

Myfab Quality Group

The aim of the Myfab quality work is to coordinate common quality interests and help each other in the local quality work. To do that, representatives from the Myfab laboratories have formed a quality group. Currently we are working with updating the introduction and safety courses, discussions how to implement a refresh safety course, and coordination meetings (telephone and in person) within the Myfab.

Strategic planning

Strategic owner group meeting on 15 February 2014

A strategic meeting with the planned Myfab IV's owner group (Dag Winkler, Mikael Jonsson, Carl-Mikael Zetterling and Lars Montelius) was held in Stockholm on 15 February. The meeting was scheduled before the SRC information meeting in order for the owner group to discuss and decide on commitments and conditions for Myfab IV. The subsequent postponing of the application date until 2015 has allowed for further strategic planning over the year, including the September meeting described below. The meeting was fruitful, and the owner group will now use the extra time available before having to apply for funding to work out strategic issues for Myfab. The owner group plans to meet once a month during spring to

Myfab annually arranges 2 – 3 workshops for strategic planning, usually with a specific topic in focus. Two such workshops have been held during 2014, one in June and one in October.

Myfab workshop 3 – 4 June at Aspenäs

Myfab's operational management and Ivan Maximov, laboratory manager for Lund NanoLab, participated in a workshop 3 – 4 June at Aspenäs, Lerum, near Gothenburg. The scope of the meeting was to discuss improvements of Myfab's operational routines, processes, projects, pricing, inclusion of Lund NanoLab, as well as strategic planning.

Myfab workshop 7 - 8 October at Trolleholm, Svalöv

Myfab arranged a workshop with organisational focus – i.e. on strategies for operations, collaboration, responsibilities, decision making, working practices etc., aiming at an even better functioning future Myfab. Participants were everyone from the owner group and operations management, and representatives from the steering board and from Lund NanoLab. The meeting took place during 7 – 8 October at Trolleholm Castle, Svalöv (close to Lund), and was led by a professional management consultant.

Owner group meeting, 10 September, Gothenburg

Myfab's owner group and a representative from Lund University met in Gothenburg on 10 September to continue the preparatory work towards the application for Myfab's fourth period of operation (Myfab IV). Because Lund University will apply together with Chalmers, KTH and UU for funding for Myfab 2016-2023, Myfab invites a representative from Lund University, to participate in the owner group meetings when relevant. Lund University's representative was Lars Montelius during first half of 2014. Anneli Löfgren replaced him in the Myfab IV owner group after the summer, and Heiner Linke is Anneli's stand-in.

Preparing for Myfab's 4th User Group Meeting in Lund, 21 – 22 April 2015

Myfab's next user meeting will take place in Lund 21 – 22 April 2015. Planning together with NorFab (Norway) was initiated in May 2014. The arrangement will have similar form as the Myfab NorFab joint user meeting 2013 in Uppsala. This time the meeting will have a stronger Nordic approach since both Denmark's (Danchip) and Finland's (Micronova) research infrastructures are invited and interested to participate and contribute. NorFab will contribute and participate to a similar extent as last time, the extent of Danish and Finnish involvement is not yet decided. Regular telephone planning meetings have been held circa every second week, starting in September. The thematic sessions will be planned through the Nordic Nanolab Expert Network's (NNEN) thematic groups, where the group leaders (from Sweden and Norway) will be responsible for the tutorials within respective theme. We have the intention that Myfab's user meeting in this way will evolve into a larger, stronger and more important Nordic Nanolab User Meeting (NNUM) where the organisations forming NNN all will contribute and share the responsibility to host meetings.

Myfab – SRC interaction

Myfab replied to SRC on their referral of a new model for support to national research infrastructures

Myfab has compiled and submitted a comment letter to SRC on their proposal of a new model for support to research infrastructures. Myfab's reply was coordinated with the replies of the Myfab host universities and Lund University.

Myfab reply to SRC on their description of Materials Science for the guide

Myfab has compiled and submitted a reply to SRC on their draft of an overview of materials science. Also Swedish ICT and Acreo Swedish ICT have submitted replies, in which they start by giving full support to Myfab's reply to the SRC. Most important in Myfab's reply was to point out the asymmetry in the original document which was focused to a very large extent on characterization methods, with very little devotion to the important area of materials (and components) synthesis. Myfab's reply was submitted on 6 October 2014.

The SRC pre-announced a call 2015 for Swedish National Research infrastructures

At an information meeting on 12 December 2014, the SRC presented some fundamental information on a call for Swedish national research infrastructures (such as Myfab).

SRC reference group meeting 9 June

Thomas Swahn participated in a Swedish reference group meeting for research infrastructures in Horizon 2020 at the SRC on 9 June. Thomas Swahn's proposed role is to coordinate input from Swedish "hardware-oriented" research infrastructures. Information meetings followed during the autumn 2014, and the main activities of the reference group will start during 2015.

MAJOR EVENTS DURING 2014

MicroNano Systems Workshop (MSW 2014) 15 – 16 May in Uppsala

Myfab participated with a presentation of Myfab (by Thomas Swahn), and a poster exhibition including a special Myfab Access desk (by Ulf Södervall). MSW is a bi-annual event, which attracted around 140 participants, and is the major Swedish event in Micro and Nano Systems Technology.

Introductory education – update meeting 15 May in Uppsala

In parallel with MSW 2014, a meeting with representatives from all Myfab laboratories, also including Lund NanoLab was held to discuss updates to the (common) introductory courses held regularly at each lab.

NanoForum, Stockholm

Myfab, represented by Nils Nordell, participated with an exhibit (roll up, brochure table and cleanroom film) at NanoForum (http://swednanotech.com/nanoforum2014), held at IVA Conference Center in Stockholm on 15 May.

ISiCPEAW, Lidingö

Myfab, represented by Nils Nordell, participated with an exhibit (roll up and brochure table and an oral presentation of Myfab at a plenary session) at ISiCPEAW (International SiC Power Electronics Applications Workshop http://www.b2match.eu/isicpeaw2014), held at Skogshem & Wijk, Lidingö, on 26-27 May.

Laboratory managers from Chalmers and Uppsala at a US conference in June

Peter Modh and Stefan Nygren participated in the UGIM 2014 Symposium (University Government Industry Micro/Nano Technology) at Harvard University, 15-17 June. This was the 20th biennial meeting in this series, where various cleanroom management issues are covered. It is clear that most of these issues are universal, and that a conference where people involved can meet, exchange experiences and present solutions that should be of interest for the continued development of Myfab and the individual laboratories.

Stockholm vision 2025

Open access research and innovation infrastructures, as a motor for innovations and industrial applications, is one of five prioritized working areas within the Stockholm County Administrative Board (Länsstyrelsen) vision to make Stockholm the world's most innovation driven economy by 2025. Electrum Laboratory is part of the project group, coordinated by Ulrika Ljungman, KTH.

Myfab Chalmers visited by MISTRA nanosafety chairman Rolf Annerberg on 28 August

Rolf Annerberg, http://sv.wikipedia.org/wiki/Rolf Annerberg, chairman of the MISTRA nanosafety project visited the nanofabrication laboratory (NFL) at Chalmers. We presented Myfab and gave a guided tour of the cleanroom.

Inauguration of the New Electrum Building October 22

From 1 August the Electrum building in Kista houses the whole KTH School of Information and Communication Technology, and an entirely new space for education has been added. This was celebrated with an inauguration party for invited guests from academia and industry. The tours of the Electrum Laboratory were highly appreciated by the visitors.

Announcement of Myfab's 4th User Group Meeting in Lund, 21 – 22 April 2015

A "save the date" announcement was prepared and distributed in November. National versions will be distributed in Sweden and Norway respectively. Denmark (DTU Danchip) and Finland (Micronova, Aalto University) were both invited during the last Nordic Nanolab Network (NNN) meeting in Copenhagen (at DTU Danchip), and they agreed to participate and to contribute.

Nordic Nanolab Network (NNN) management and Nordic Nanolab Expert Network activities 2014

The directors and lab managers and technology experts of Myfab, NorFab, Micronova and Danchip have had several meetings and interactions during 2014, the most important such events are described under International Collaboration below.

Myfab LIMS – Southampton visit to Chalmers 11 December

Southampton Nanofabrication Centre visited Chalmers on 11 December. We had a long discussion about running infrastructures as we do and also about Myfab LIMS. They are in a process of deciding their route (using existing software such as Myfab LIMS or to develop their own). They stressed flexibility and also suggested another model for Myfab LIMS based on their experience of developing ePrints (a repository system) that they now run as an open source software. Southampton has access to Myfab LIMS's evaluation environment for test.

Planning for installation of Myfab LIMS for CNRS LAAS in Toulouse

Myfab is now about to start installation of Myfab LIMS for CNRS LAAS in Toulouse. Currently, non-disclosure agreements are set up and after both parties have agreed on the formulations, the installation will begin during first half of 2015.

MYFAB'S CLEANROOM LABORATORIES

KTH – Electrumlab

The renewal of lab space and tools is continuously on-going. Obsolete tools were replaced in the beginning of 2014 by: an Endura Platform from Applied Materials with three chambers for metal sputtering (financed by a KTH user group), a one tube furnace for deposition of in situ doped polysilicon (financed through the lab budget, i.e., by user fees), and a reactor for epitaxial growth of SiC delivered to a spin-off company and installed in the cleanroom.

Thanks to a generous grant from the Knut and Alice Wallenberg Foundation (KAW), Albanova NanoLab expanded its instrument park of Scanning Probe Microscopes with four new instruments. These are placed in a new laboratory space, and are fully open to all trained users. Technical support staff is in place to assist one-time users, and train new users. The microscopes offer a wide variety of extension modules, including some unique methods developed in-house, known under the name Intermodulation Atomic Force Microscopy (AFM). The group of Materials Physics has been approved a grant from KAW Foundation for time resolved transmission electron microscopy. The custom designed microscope will be installed in the beginning of 2015.

The yearly user satisfaction survey for 2014 has been completed and the weighted level of overall of satisfaction remains high; 3.1 (of a maximum of 4.0), which is the same level as for 2013.

KTH introduces an environmental management system according to the ISO14001 standard. Electrum Lab is well prepared for this step through the ISO9001 certification. The energy consumption in the labs will be reduced by introducing LED lights.

Uppsala - Ångström - MSL

During 2014, much time and effort has been spent to establish a new unit for nanopatterning and –structuring. This is built around the new electron beam lithography tool (NBL nB5), which has been installed in a separate module within the lithography area. The lab layout has been modified, existing tools have been relocated, wet benches have been rebuilt for new chemistries and processes, and dedicated peripherals (spinner, hot plate and chemical baths) have been added. A major addition to this unit is a combined PVD and etch tool, purchased from the Mid Sweden University, where the etch chamber will be rebuilt from RIE to provide ion beam etching.

Other tools that were purchased and/or delivered include a sputter, primarily intended for solar cell projects, an ion polisher for sample preparation, a spectroscopic reflectometer and a stylus profiler.

Chalmers – NFL

In February NFL recruited a third researcher working on nanolithography. He is responsible for the procurement of our new electron-beam lithography system financed by the Knut and Alice Wallenberg Foundation (KAW). During 2014 we have commissioned a direct-write laser lithography system, also financed by KAW. It has already proven to be a very versatile complement to our existing lithography tools and attracted over 30 users in a couple of months. During 2014 NFL has procured or prepared procurements for another seven tools of which three will belong to the Graphene Innovation Lab, now being built inside NFL.

We have performed a study on presence of nanoparticles inside NFL. The result is very good; we have almost no nanoparticles present in the cleanroom. We typically measured between 0 and 1 particles per cm^3 compared to ≈ 5000 outside in open air (1500 in offices).

NFL has initiated mandatory project start up meetings for new users and projects, where a plan for the first three months of the project will be established. The plan includes a process plan and a training plan. This will reassure that the project starts up in the right direction and that the new users get training needed on relevant tools from the start.

COMMUNICATION

The overall communication strategy is to strengthen the image of Myfab as an open, flexible, world-leading and reliable infrastructure for micro and nanofabrication, with the aim to position Myfab as the first choice for experimental nanofabrication in Sweden. Myfab's most prioritized target group is researchers at all levels within the academic system, but also at high-tech companies, mainly start-ups, and other companies that perform research. The aim is that Myfab will become increasingly visible to a broader target group, especially toward new users in small and medium-sized companies and within academia, to funding agencies and the general public.

To this end, during 2014, Myfab continued to invite researchers, industry and the public to visit our laboratories and gaining an understanding of which resources are available in Myfab.

OUTREACH ACTIVITIES

Swedish Microwave Days & GigaHertz Symposium 2014

Myfab participated with an exhibition using roll-ups and folders at the GigaHertz Symposium, which was held in Gothenburg during the Swedish Microwave Days (www.microwavedays.se) 11 – 12 March.

NorFab's International Advisory Board meeting

Myfab's director participated in NorFab's advisory board meeting during 31 March – 1 April in Oslo. NorFab was inaugurated in 2010 and is with respect to mission and operation arranged very similarly to Myfab. Especially interesting to us is that NorFab has developed common pricing and guidelines for investments further than Myfab.

ULIS 2014

Myfab participated with a small exhibition with roll-ups and folders at the 15th edition of the International Conference on Ultimate Integration on Silicon (ULIS), 7-9 April, 2014 at the Stockholm Waterfront Congress Centre, Stockholm, (www.ulisconference.org).

Scandinavian Electronics Event 2014

Myfab was promoted in the Acreo exhibition at the Scandinavian Electronics Event, in Kistamässan 8-10 April (www.see-event.se). Tours of the Electrum Laboratory were organized daily for the participants of the fair.

Brazilian Delegation visits Myfab at Chalmers

On 22 September, a Brazilian Delegation of about 15 persons from Brazilian academy, industry and politicians from São Bernardo do Campo (SBC), State of São Paulo, visited Myfab at Chalmers. This was part of a larger programme arranged by Business Sweden, where the delegates also visited the vehicle industry in Gothenburg, Stockholm and Linköping. The delegation had a specific interest in nanotechnology and nanoscience in Sweden and contacted Myfab through Business Sweden to set up the visit. The visit was also made in the context of Brazil's interest of Sweden's fighter aircraft Gripen. We presented Myfab, some selected

academic and commercial projects and arranged a guided tour through the MC2 Nanofabrication Laboratory. A few weeks later, Myfab received its first official thank-you letter ever! See attachment.

Future Friday 2014

KTH school of ICT in Kista organizes a yearly event for high school students to attract new students to KTH. The program includes seminars, an exhibition of companies and KTH projects, and tours of the Electrum Lab. This year 123 students joined the lab tours.

The International Science Festival in Gothenburg 2014

The Nanofabrication Laboratory and MC2 as usual hosted the very popular 'Nanoscientist for a day' during the International Science Festival. During the activity, one class of 11 year old schoolchildren visits the cleanroom each day for some hands on experiments.

Lund NanoLab

National collaboration on the Myfab level is particularly strong with Lund NanoLab (LNL). For more than five years, LNL has been operating in a way very similar to Myfab, e.g. by using Myfab LIMS for tool booking. Also, other Swedish and European laboratories use Myfab LIMS in their operation.

SwedNanoTech

Myfab is a founding member of SwedNanoTech, the umbrella organisation for Swedish nanotechnology actors with the goal of increasing the knowledge of nanotechnology in a broad sense.

The International Science Festival in Gothenburg

MYFAB ACCESS

Myfab Access offers free access to the cleanroom facilities for a limited test or start-up project. The aim is to make potential new users aware of the resources available through Myfab and the major opportunities that exist for companies to get assistance in developing innovations in their respective areas of operation.

Interested users can apply for a project grant via a fast track application procedure. A program selection panel evaluates and distributes the funding based on project quality. The program gives priority to users from Academia and SMEs, which are expected to be long term users. The program manager for Myfab Access is Ulf Södervall, Chalmers (former project manager for FP6 MC2 Access), and the program selection panel consists of six device and fabrication experienced researchers (two from each Myfab laboratory).

Activities

All together 12 projects have started up within the Myfab Access program since the activity started in March 2013. Most projects have been academic projects, while only two project funds were granted to start-up companies. During 2014, four new projects was funded and started up. The total usage in 2014 for all Myfab facilities has been more than 600kkr (tool costs, travel costs and accommodations). Four projects have finished their Myfab Access activities; three during 2013 and one project during 2014. Of these have two projects decided to prolong their activities in Myfab facilities using own financial resources. A major part of the projects and lab activities have been made at the MC2 node. Most work has been made by PhD students, with assistance from laboratory staff on the individual sites.

The Myfab Access program has during 2014 promoted new common activities with external universities (Umeå and Linköping), and the collaboration is getting more advanced. A knowledge of nanofabrication is built up at those sites, which in the future will strengthen interactions and make usage easier for remote users and new non-experienced user groups. Another fruitful outcome from the program has been the possibility to widen the field of users to new research areas such as chemistry, medicine and commercial production. During the first two years of the program new research technologies as microfluidics, nanoparticle self-alignment, innovative decorative jewellery and medical applications have been initiated.

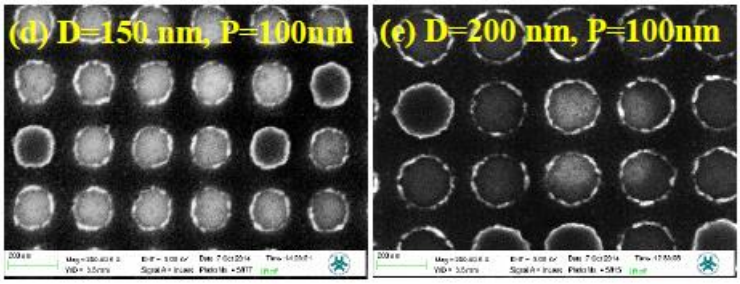
The program has also gained valuable and important feedback input from the new users to optimize the facilities' resources, such as better overview about resources on the different sites, and suggestions for new equipment required from new type of users.

A few examples of projects that are ongoing or completed during 2014 are described below.

Application within photonics, using world class EBL equipment – Ching Lien Hsiao, Linköping

This project is focused specifically on the optimization of nanohole patterning process on GaN templates using Ti masks. The patterned templates will be used to grow GaN nanorods in the magnetron sputter epitaxy system at Linköping University. The IFM group has got extensive on-site training for the needed equipment for electron-beam lithography (EBL) at MC2 at Chalmers. A PhD student now works independently to produce needed patterns, despite no previous experience on EBL process before the project started. The EBL process will benefit a lot to her PhD study on III-nitride semiconductor nanostructures.

Result: So far the group has successfully made nanohole (100-200 nm) patterns on GaN templates. Adhesion problem at Cr/GaN interface has been solved and considerable optimization of the e-beam exposure conditions has been done. However the aim is to reach to even smaller structures, at least 50 nm. Two separate techniques are studied, lift-off and Etch, for pattern transfer. So far Lift-off seems most promising.



Nanohole pattern in Ti on GaN substrate fabricated by electron beam technology.

Application of microfluidics cells for disease diagnostics – Thomas Wågberg, Physics, Umeå

This project conducts a complex and integrated study of neurodegenerative pathology, integrating molecular, cellular and organism levels, with particular focus on amyloid formation and inflammation. The project focuses on developing micro and nanofluidic devices to study amyloid assembly at nanoscale and provide insight into nanoconfinement phenomena such as exclusion volume, modified velocity, steric, regulatory interactions and others, mimicking the synaptic cleft. The ultimate goal is to use this knowledge for effective diagnostics (especially early stages) and therapeutics based on active component in Chinese medicine and to develop early diagnostics based on microfluidics biosensors.

Results: The project has started up with contacts to MC2, Chalmers, and has participated in the preparation of the process to achieve a "master" for developing nanochannel arrays (first prototype has a channel width of 200 nm). The goal is to study confinement in the range 100

nm-1 μm. Photomasks have been fabricated at Ångström clean room for optimizing the PDMS bonding process. The final optimization procedure is achieved at the in-house clean room at the Physics department, Umeå University.

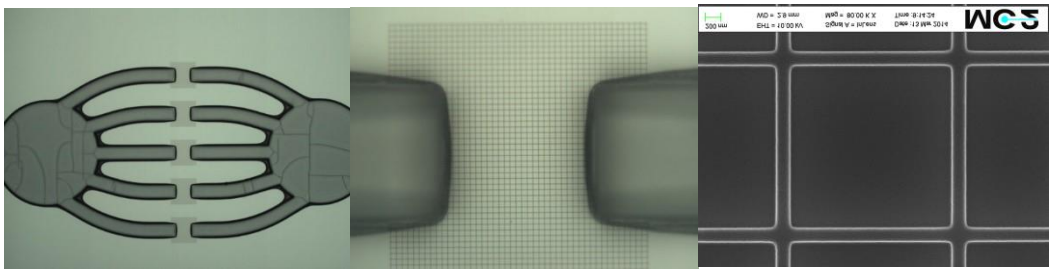


Figure: Ebeam fabricated nanochannels.

Application within nanotechnology for decorating jewellery with images – Carolina Claesson, HDK, Gothenburg

This comprises development work to find and use new nanotechnologies within Jewellery Art and Design. The focus has been on transferring photos/images to gem materials (e.g. rhinestone-rock crystal). Challenges in jewellery and using precious stones are e.g. sample surfaces that are not flat, the existence of adhesion problems and also environmental exposure resulting in mechanical wear. Different metals, such as Pt, Pd, Ti, Au, Ag and Al have been the main elements of use, and different deposition techniques have been used to optimize the process. The technique of transferring images is also a non-trivial topic on these types of samples. A proper choice and combination of materials that can give good contrast must be chosen. The standard technique of photolithography was used.

Result: Several successful results have been achieved with different material combinations, and especially Ag gives very useful and promising results, see images below.

Left picture: The sample on the left (more bright) is made by silver on rock crystal and to the right (less bright) by aluminium on rock crystal. Right picture: Titanium oxide on silver, and after that enamel as passivation on top.

Application of controlled nanoparticle self-alignment – Kasper Moth-Poulsen, Chalmers, Gothenburg

Future transistors and other electronic parts in logical circuits must decrease in size to get stronger and faster processors in computers. It must be possible to process single molecular transistors in parallel in order to attract the industry, as classical top-down lithographic methods cannot be used. One way of avoiding the difficulties with top-down methods is to make use of direct self-assembly of single molecular electronics. The group has developed a method and a theory of how this is manageable but cleanroom techniques must be used in order to make this project successful. We have developed a method where we can design and synthesize nanoparticles in different sizes and geometrical shapes, all from spheres to cubic shaped particles. The particles are generated and kept in solution, they are covered with a surfactant which makes them positively charged, this surfactant will keep the particles from agglomerate since they repel each other. The idea is to link two of these nanoparticles with a specially designed molecule which can act as a diode, switch and transistor and even as a plasmonic sensor. These particle complexes or proto-devices are generated through self-assembly in solution. However they must be deposited onto a wafer with designed electrodes in order to be able to construct a larger device.

The preliminary results are: a) it is possible to guide particles using PMMA windows designed in EB, b) the deposition of particles can be controlled by changing the substrate, which confirms that the particles are charged in solution and during deposition, c) it is possible to separate single particles into smaller features, and d) it is possible to trap single particles.

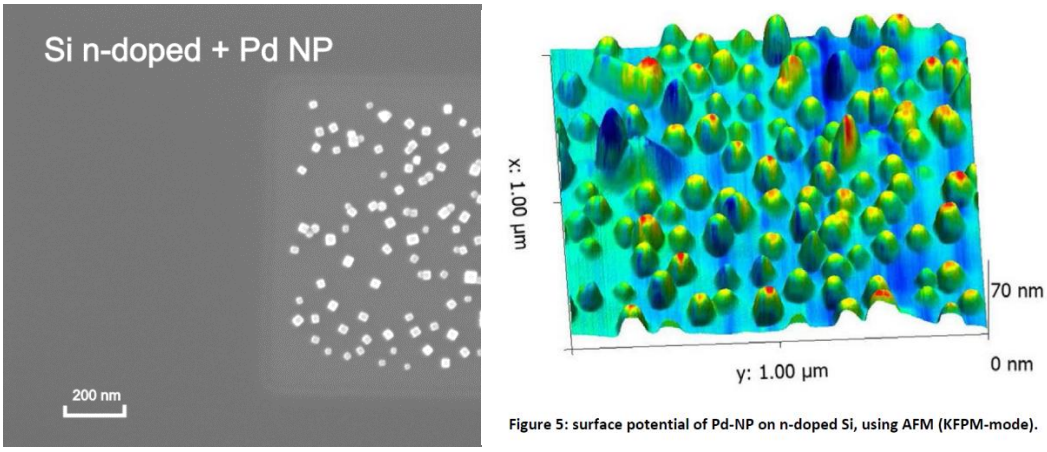


Figure 5: surface potential of Pd-NP on n-doped Si, using AFM (KFPM-mode).

Figure: Pd nanoparticles in windows of PMMA on n-doped silicon.

Application of thin organic films for PV applications – David Barbero, Physics, Umeå

Due to their optical absorbance and their ability to transport charges, semiconducting polymers such as the widely used poly-3-hexylthiophene (P3HT) have been successfully used in organic photovoltaic solar cells (OPVs) and in field effect transistors (FET/TFTs). Thin films of these polymers are typically formed by spin-coating from solution onto a substrate. The properties of this thin polymer layer strongly depend on its crystallinity and internal nanostructure, which is partially determined by the interactions between the polymer chains and the substrate. An interest in studying and controlling the microstructure of these thin layers has been the major goal of this Myfab Access project.

Results: SEM analysis of different microstructures of TiO2 has been done at MSL, Uppsala, and characterisation on very thin films with XRD has been done at MC2, Chalmers. Additionally, metal-coated flexible electrodes were fabricated using the thermal evaporation system. The vertical conductivity through the P3HT micropillars was measured. See the SEM image of the contact pad between the flexible mold and the P3HT micropattern.

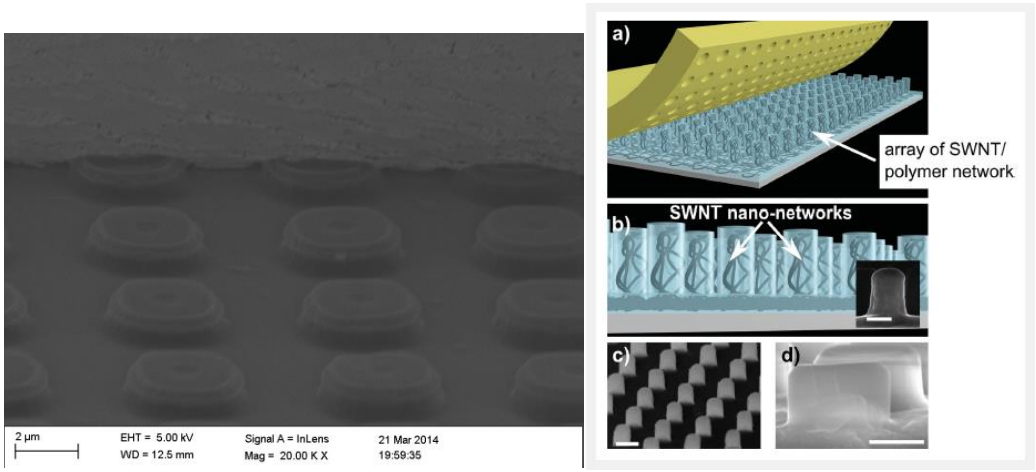


Figure: Scanning electron microscopy image of the contact pad between the flexible mold and the top surface of the P3HT micropattern.

Application of liquid transport mechanisms in microchannels – Johanna Andersson, Chemistry, Chalmers, Gothenburg

This project wants to study the nature of capillary action in nanostructured microchannels with different hydrophobicity with the aim to transfer the knowledge into a real system using renewable materials with increased mass transport properties. A microfluidic device that works with capillary action has been fabricated in silicon. The scalloping effect from different degrees of roughness of walls will be achieved by changing the etching parameters.

Results: Design work was first done for the first mask/pattern to etch the holes through the wafer. Etched holes using ICP plasma etching all the way through a 4 inch wafer; 100, 70 and 50 µm in diameter. Second step was to design the actual mask with connection channels for the liquid, which in addition to the channel holes also included the connection channels on top and bottom. Almost all steps of the creation of a microfluidic device have been conducted. The masks were drawn and ordered and, in several steps, photoresist was applied on a 4 inch wafer and etched using ICP. See the planned device in the figure below.

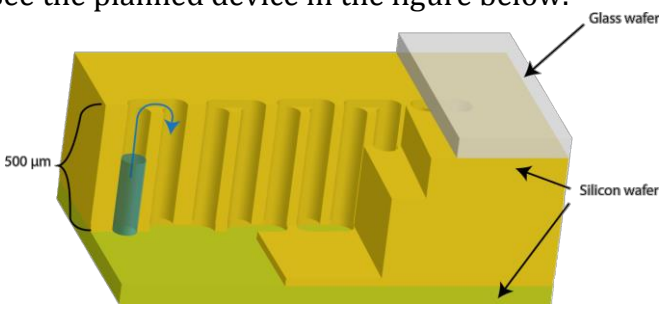


Figure: 3D-Drawing of the planned microfluidic device: holes of different diameters etched through the wafer with connection channels at top and bottom. To close the device, a silicon wafer will be bonded on the bottom and (for optical access) a glass wafer on the top.

INTERNATIONAL COLLABORATION

Nordic Nanolab Network (NNN) management meetings

The Nordic collaboration has deepened and widened during 2014; Myfab and NorFab initiated in Oslo in May the Nordic Nanolaboratory Network (NNN), where the management of the national nanotechnology research infrastructures of Sweden, Norway, Denmark (Danchip) and Finland (Micronova) meet to exchange experiences, best practice and to plan collaboration. Iceland has no corresponding organization but NNN will be open for Icelandic participation.

NNN management meeting 21 – 22 May at SINTEF/UiO, Oslo

The operation managements of Myfab and NorFab met during a lunch-to-lunch meeting in Oslo on 21 – 22 May. Also a representative from Danchip participated. Several collaborative projects and topics were discussed, including formation and start of thematic groups within the Nordic Nanolab Expert Network (NNEN), the joint user meeting in Lund during spring 2015, collaboration related to Myfab LIMS, the need for process and project support, common challenges in operations, application etc.

NNN management meeting 4 – 5 November at DTU Danchip, Lyngby, Copenhagen.

This second NNN meeting was held in Copenhagen during 4 – 5 November, and was the first meeting with participants also from Finland. Each country gave updates and overviews on their most important activities. The most important presentation was from Norway and NorFab, who recently applied for funding for a five year period, 2015 – 2019. The planning for the Nordic Nanolab Expert Network (NNEN) was discussed and updated. Currently three thematic groups – Dry Etching, Lithography, and Thin Film – has been started, and in January 2015 a fourth group, preliminary named "Characterization in cleanrooms" will be started at a first meeting at DTU Danchip. The establishment of a fifth group – an infrastructure group – oriented towards fundamental questions for the cleanroom technical staff – de-ionized (DI) water, fans, gas handling, laboratory safety etc. – was also discussed. A common homepage will be set up for the NNEN-groups; Myfab's Peter Modh looks into that. Jörg Hübner from DTU presented how Danchip uses Balanced Score Card monthly to monitor 18 parameters and goals for the organisation. The third NNN meeting will be arranged in Gothenburg preliminary in June 2015 and will be hosted by Myfab.

Nordic Nanolab Expert Network (NNEN) – thematic groups and meetings

The Nordic Nanolab Expert Network was started on 13 November 2013 when the thematic group NNEN dry etch started as pilot study at a meeting at Chalmers. The idea to start a Nordic expert network emerged from the management and from the experts involved in arranging the tutorials at Myfab's and NorFab's User Meeting in Uppsala in April 2013. Four NNEN thematic groups has since been formed, three of which have had one or several meetings during 2014, and one which is planned to start in January 2015. They are all formed and managed based on the experiences from the successful start of NNEN dry etch, i.e. the groups consist of about 15 – 20 experts each, they meet once or twice at a cleanroom laboratory annually to exchange experiences, discuss technical problems, make clean-room visits, plan activities etc. The praxis

is that a lab volunteer to host a meeting, recommend hotel and arrange a dinner, and the participants cover their own expenses for travel and accommodation. In-between meetings, the on-line web-forum Basecamp is used for interactions.

Nordic Nanolab Expert Network (NNEN) Dry Etch 2nd meeting in Copenhagen 23 – 24 April)

The second thematic meeting of NNEN dry etch was arranged by Danchip in Lyngby (Copenhagen) with around 20 participants from the Nordic nanotechnology laboratories. This meeting focused on solutions for process and machine configuration related problems. All NNEN thematic groups use Basecamp to organize their presentations, agenda etc. Furthermore, Basecamp provides a discussion forum which has been frequently used since the first meeting at Chalmers. The dry etch group plans for the 3rd meeting in November, then meetings will be held once a year.

NNEN Lithography kick-off in Trondheim 1 – 2 September

The first meeting of NNEN lithography was arranged by NorFab/NTNU in Trondheim with around 20 participants in total, 1-4 participants from each laboratory. For this first meeting focus was on introductory presentations of/by each participating laboratory and more specific presentations of the lithography resources in the respective laboratory. The lithography group is now set up and organized on Basecamp. The second lithography meeting was decided to be arranged by Lund NanoLab in March 2015.

NNEN Thin Film kick-off in Uppsala 1 – 2 October

The first NNEN thematic meeting for thin film deposition techniques was arranged by Myfab Ångström Laboratory in Uppsala with almost 20 participants. This first meeting focused on general introductory presentations of/by each participating laboratory, and more detailed presentations on the thin film deposition capabilities in respective laboratory. The thin film group is now set up and organized on Basecamp with several ongoing discussions. The second thin film meeting is planned to be held in Oslo in September 2015, and the third meeting in Espoo 2016.

NNEN Characterization in cleanroom starts 2015

A decision was made to start an additional NNEN thematic group: “Characterization in cleanroom”, the first meeting is scheduled to January 2015 and will be hosted by DTU, Lyngby, Denmark.

LAAS-CNRS (RENATECH) meeting at Chalmers

Hugues Granier visited Myfab at Chalmers during 17 – 18 February. The topic for the meeting was collaboration between Myfab and RENATECH, especially LAAS-CNRS in Toulouse, on software tools. Hugues Granier presented Sultan, a software for process definition developed by LAAS, and which is of interest for Myfab. The Sultan software is in a development stage, but most fundamental features are already there. Such a software tool would be a great benefit for Myfab. LAAS also shows a strong interest in Myfab LIMS, and an evaluation account was set up for LAAS/RENATECH so they can test and evaluate the tool. Also discussions on collaboration around H2020 was held.

Technet_nano

The EU financed Technet_nano project was finished in March. The project's goals were to build a network of Baltic Sea region cleanrooms as a base for future collaboration projects and for promoting nano- and micro fabrication facilities to small and medium size companies. At the end of the project a total number of 140 site visits from SMEs were made at the participating labs, which had resulted in more than 60 projects. Discussions about EU funded research projects are also initiated among the partners. One of these is the CAMART2 project within the Horizon 2020 WIDESPREAD – 1 – 2014 call, with University of Latvia, KTH, and Acreo Swedish ICT as partners. This project has been approved, and the project start is planned for June 2015.

SiNANO Institute

The Myfab laboratories are members in the SiNANO institute (http://www.sinano.eu/). The SiNANO Institute is a non-profit association aiming at establishing a durable EU Network of researchers in order to form a distributed Centre of Excellence in the nanoelectronic field. More than 1200 scientific and technical staff is working together in this field in the SINANO Institute.

QualityNano (Earlier.QNANO)

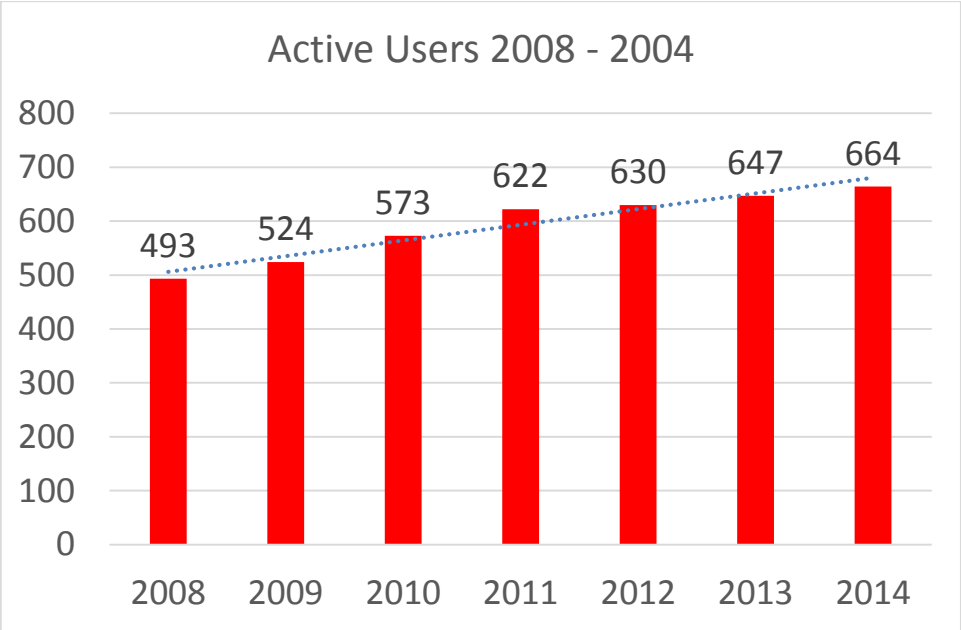
The EU-funded infrastructure for nanomaterial safety testing aims to create an integrated hub for nanosafety research within Europe. Together with 27 other top European facilities in nanotechnology, medicine and natural sciences, Myfab Ångström participates in joint research activities and provides transnational access to the lab resources. The project ends in February 2015.

SPECIFIC POINTS REQUESTED BY SRC IN THE ANNUAL REPORT

In the contract between the Swedish Research Council and Myfab, it is stated that Myfab should address the ten points listed below in the annual report.

1. Number of users, including new groups

Myfab introduced its in-house developed Myfab LIMS system by 1 January 2008 in all Myfab laboratories, and we have thus used the system during seven full years now. The number of active users shows an increase over the years, and has now reached 664 users. An active user is a person who personally was performing at least one activity in a Myfab laboratory, *i.e.* a person who has the competence to perform such work and who dresses up and enters into the cleanroom.



At KTH one new academic group from KTH and one from Linköping University, as well as four new companies and one research institute started to use the laboratory during 2014. At Chalmers, four new academic user groups, from Umeå, Lund and Linköping, and two new companies started to use the cleanroom with own personnel. In Uppsala one new user group and two new companies used the MSL cleanroom.

2. Major changes to the organisation

<u>New representative in the Myfab Owner Group</u>

Carl-Mikael Zetterling replaced Mikael Östling as KTH's representative in Myfab's Owner Group, as a natural step as Mikael has retired after serving as Dean for the School of Information and Communication Technology (ICT). Carl-Mikael Zetterling professor in Solid State Electronics at KTH and vice-dean of ICT, is very familiar with Myfab and the Electrum

Laboratory, so we expect a ”seamless” transition of responsibilities within Myfab’s Owner Group.

Change of communications and project management staff

Myfab’s communications manager Christina Caesar finished working for MC2 and Myfab on 1 September. She was replaced in part by Michael Nystås, who started on 22 September as new communications officer for MC2 and Myfab. Michael has 15 years’ experience from different departments within Chalmers, most recently from the Communications and Marketing office, and from a broad range of tasks, among others Chalmers homepage, Chalmeristbloggen, and Chalmers Twitter.

Dr. Cristina Andersson, responsible for external and commercial relations at MC2, now supports Myfab with most communication tasks such as being part of the operations team, attending steering group meetings, participating in the planning of the user group meeting etc.

3. Number of peer-reviewed articles related to the infrastructure = 671

The number of peer-review articles by authors or projects using Myfab during 2014 is 671, an identical number as 2013, and an increase from 627 in 2012. The number is the result from a process where each publication is manually selected if the work reported is based on Myfab usage to a significant extent, using data lists from available databases at the participating universities, which are compulsory for the affiliated staff to keep updated. Currently, Myfab does not have a routine of its own to register publications, so the actual number of publications is likely to be higher than we report here.

4. Number of patents related to the infrastructure

Myfab has about 650 active users who bring about project activities involving 1500 – 2000 persons or even more, taking into account that each active Myfab user typically collaborates with 2 – 3 persons when outside the cleanroom laboratory. This extensive group of researchers and entrepreneurs is spread around a large number of research groups and companies. It is not mandatory for Myfab users to report patents emerging from the infrastructure, and neither is there a process through which patents or other IP rights are gathered. The reason for this is that Myfab does not track nor control the use of results among its users. The number of patents is therefore difficult to determine, and we are not prepared to answer the question in any other way than this.

5. Economical account including other major contributions applied for or received

The total operations grant during 2014 from SRC was 31 000 000 SEK. Most of the funding was distributed to the three Myfab laboratories according to the established key number (so called X-funding): Chalmers 40%, KTH 30% and UU 30%. The corresponding amounts are: 10 500 kSEK, 7 875 kSEK and 7 875 kSEK, total: 26 250 kSEK. 1 500 kSEK was distributed to the further development of the Myfab LIMS and Myfab’s website. The sum of administrative costs 2014 is 4 150 kSEK which includes remuneration to the steering board, salaries to the director and communication officer, consultant costs, advertising, information, printing costs, travel expenses, rent for premises etc. The LIMS costs for support and development was 1 875 kSEK 2014. Below we present separately the budgets for Myfab’s laboratories, including economical support from the 2014 SRC grant.

Income [kSEK]	Electrum	NFL	MSL[5]	All Myfab labs
Faculty grants	12 200	25 742	10 886	48 828
Fees, academic	18 550	16 860	4 870	40 280
Fees companies incl. Acreo	15 600	4 468	4 414	24 482
Myfab SRC grant	7 875	10 500	7 875	26 250
Financed depr.	5 420	9 841	2 508	17 769
Services	1 000	0	0	1 000
Income Total	**60 645**	**67 411**	**30 553**	**158 609**
Costs [kSEK]				
Personnel	13 200	15 066	7 165	35 431
Rent premises	10 500	17 638	11 100	39 238
Operation	20 330	11 762	5 260	37 316
Overhead	5 240	4 824	2 032	12 096
Financed depr.	5 420	9 841	2 508	17 769
Depreciations	5 720	8 294	3 351	17 365
Costs Total	**60 410**	**67 425**	**31 416**	**159 251**
Result	**235**	**-14**	**-863**	**-642**

The total turnover of the three Myfab laboratories was 159 251 kSEK, in which 26 250 kSEK from Myfab's operations grant (of a total of 31 000 kSEK) is included. Myfab's operation grant is 19.5 % of the laboratories' total revenues, and its contribution directly to laboratory operation is 16.5 %. Myfab's total turnover, including administrative costs and external costs for support systems (LIMS, homepage) and Myfab Access is 159 251 + 4 150 + 1 875 kSEK = 165 276 kSEK.

[5] *In the compilation for Ångström Microstructure Laboratory, the budget for Ion Technology Center (ITC) is not included.*

6. International contacts and collaborations

In the European arena, Myfab is strengthening the bilateral collaboration with other national research infrastructure networks. The collaboration with the Norwegian NorFab is well developed, with common management meetings.

The Nordic Nanotechnology Expert Network (NNEN) was started by Myfab and NorFab in 2013. Experts from all Nordic countries meet and exchange knowledge, best practices, make cleanroom visits and thus form a grass-root network of experts in topical fields.

Typically, the NNEN meetings are attended by 15 - 20 participants from ten of more nanotechnology laboratories in the Nordic countries. A web discussion forum is set up for each of these groups (Basecamp), which is frequently used for problem solving and planning.

The Nordic collaboration has deepened and widened during 2014; Myfab and NorFab initiated in Oslo in May the Nordic Nanolaboratory Network (NNN), where the management of the national nanotechnology research infrastructures of Sweden, Norway, Denmark (Danchip) and Finland (Micronova) meet to exchange experiences, best practice and to plan collaboration. A second NNN meeting was held in Copenhagen in November.

Myfab will in April 2015 arrange a user meeting in Lund, together with NorFab. At this meeting, the NNEN thematic groups take special responsibility for a series of technology tutorials.

At the NNN Copenhagen meeting it was decided that also Danchip and Micronova should contribute and their users should be invited to participate. Myfab's user meeting will, we discussed, evolve into a Nordic Nanolaboratory User Meeting (NNUM). Further planning will be made during future NNN meetings.

The Myfab nodes are members in the SiNANO institute and participate in the technology platforms of Photonics 21 and ENIAC, and are also members in a number of EU funded infrastructure related projects, e.g., QualityNano (Uppsala University) and Technet_nano (KTH). Through KTH, Myfab participates in the cleanroom platform collaborative network since 1997, where representatives from eight European laboratories meet twice annually.

See also the INTERNATIONAL COLLABORATION section above for more details.

7. To what extent the scientific goals have been achieved, or new revised goals

Myfab is a research infrastructure which provides access to a large number of tools for fabrication and characterisation, expertise on process flows and individual tools, as well as on a wide range of applications. Myfab does not produce scientific results itself; its mission is to support users from academia and industry to achieve their goals. Myfab's goals are therefore managerial and technical rather than scientific. From that point of view, Myfab has very well achieved its goal to provide top class, cleanroom-based resources for microtechnology and nanoscience, supporting an increasing number of researchers and innovators in achieving world-class results and developing products for the needs of society.

8. Major scientific breakthroughs

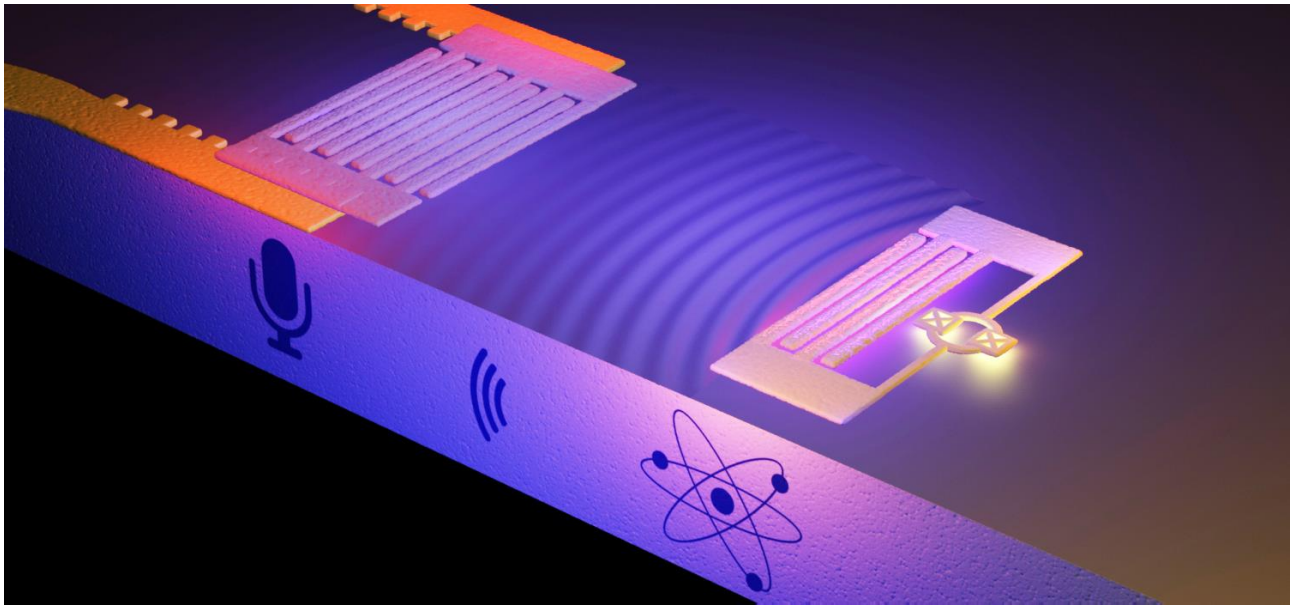
The examples listed below have in all cases used Myfab facilities to some extent.

The sound of an atom has been captured

Researchers at Chalmers are first to show the use of sound to communicate with an artificial atom. They can thereby demonstrate phenomena from quantum physics with sound taking on the role of light. The interaction between atoms and light is well known and has been studied extensively in the field of quantum optics. However, to achieve the same kind of interaction with sound waves has been a more challenging undertaking. The Chalmers researchers have now succeeded in making acoustic waves couple to an artificial atom. The study was done in collaboration between experimental and theoretical physicists.

Gustafsson, M. V.; Aref, T.; Frisk Kockum, A. et al., Propagating phonons coupled to an artificial atom (2014). Science, 346, 207 (2014); DOI:10.1126/science.1257219.

More information: www.chalmers.se/en/news/Pages/The-sound-of-an-atom-has-been-captured.aspx



On the right, an artificial atom generates sound waves consisting of ripples on the surface of a

solid. The sound, known as a surface acoustic wave (SAW) is picked up on the left by a "microphone" composed of interlaced metal fingers. According to theory, the sound consists of a stream of quantum particles, the weakest whisper physically possible. The illustration is not to scale. Image: Philip Krantz, Krantz NanoArt.

Development of a comprehensive Graphene FET Model for Circuit Design

Based on devices and circuits processed at Electrum Laboratory a comprehensive Graphene FET Model for Circuit Design was developed by researchers at KTH Royal Institute of Technology. The results show that the proposed model follows closely to both the complete analytical model and the measured data; therefore, it can be successfully applied in the design of GFET analogue circuits.

Rodriguez, S. ; Vaziri, S. ; Smith, A. ; Fregonese, S. ; Östling, M. ; Lemme, M.C. ; and Rusu, A., A Comprehensive Graphene FET Model for Circuit Design (2014). IEEE Transactions on Electron Devices, 61(4): 1199-1206, (2014); DOI: 10.1109/TED.2014.2302372.

Spintronics with hBN-Graphene van der Waals heterostructures

Heterostructures of graphene and hexagonal boron nitride (h-BN) have recently emerged as promising nanoelectronic architectures due to their complementary electronic properties and structural compatibility. Researchers at Chalmers expand the functional horizon of such heterostructures by demonstrating the quantum tunnelling of spin polarized electrons through h-BN barrier into graphene. Excellent tunnelling behaviour of large scale CVD h-BN layers together with tunnel spin injection into graphene using ferromagnet/h-BN/graphene van der Waals heterostructures are realized. In these devices, the researchers demonstrated spin transport and precession with enhancements in both spin signal amplitude and lifetime by an order of magnitude. The integration of h-BN spin tunnel barrier to graphene provides a unique and important method to circumvent the challenges involved in the growth of conventional ultra-thin oxide tunnel barriers and opens up new avenues for efficient spin based memory and logic applications.

Kamalakar, M.V.; Dankert, A.; Bergsten, J.; Ive, T.; and Dash, S.P., Spintronics with graphene-hexagonal boron nitride van der Waals heterostructures (2014). Scientific Reports (Nature Publishing) 4, 6146 (2014); Applied Physics Letters 105, 212405 (2014); DOI: 10.1063/1.4902814.

Unique solution for passivating the back contacts of CIGS thin film solar cells

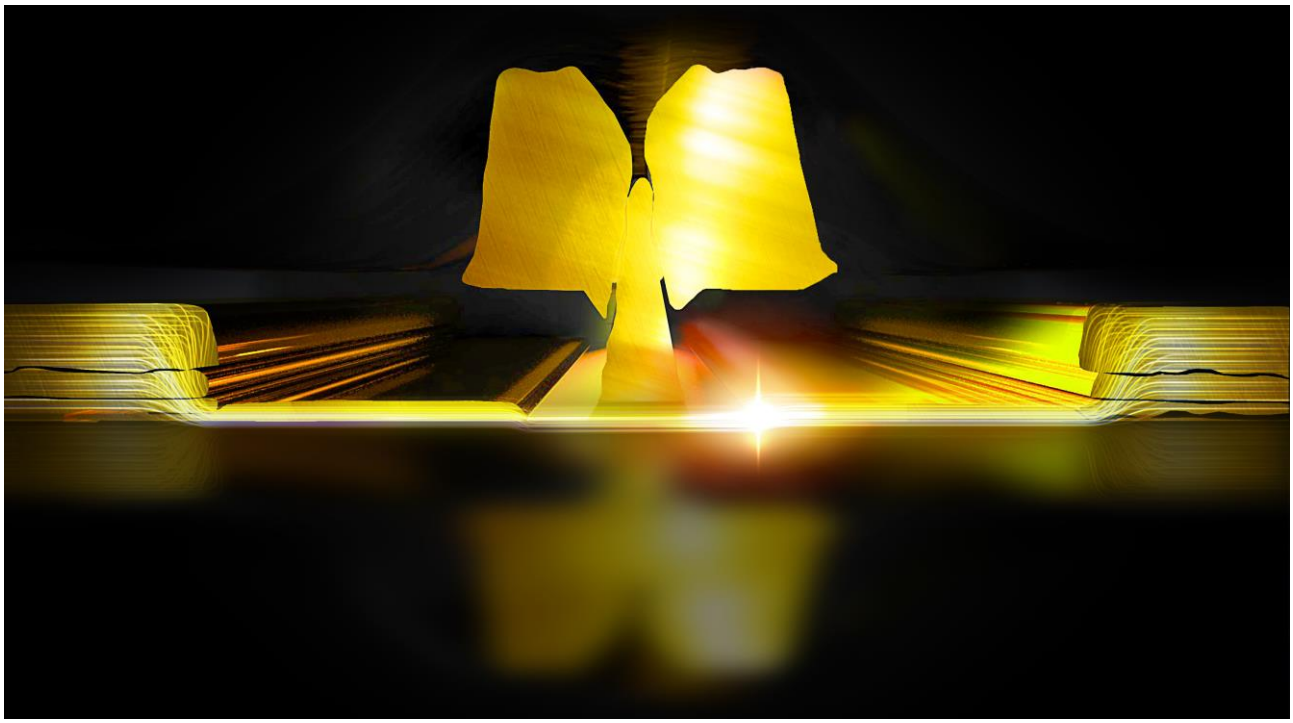
Researchers at the Myfab-Ångström laboratory have reached a breakthrough with a unique solution for passivating the back contacts of CIGS thin film solar cells. With this technique the CIGS layer thickness can be reduced to below 300 nm with maintained voltage level. Current loss caused by the thin absorber layer can be limited by an optical reflector, consisting of matched layers of aluminium oxide and magnesium fluoride. The aluminium oxide also serves as a passivating layer and thus has a double function.

Vermang, B. ; Wätjen, J. T. ; Fjällström, V. ; Rostvall, F. ; Edoff, M. ; Kotipalli, R. ; Henry, F. ; and Flandre, D. (2014), Employing Si solar cell technology to increase efficiency of ultra-thin Cu(In,Ga)Se2 solar cells (2014). Prog. Photovolt: Res. Appl., 22, 1023–1029 (2014); DOI: 10.1002/pip.2527.

Noise in a microwave amplifier is limited by quantum particles of heat
In a collaboration with Caltech and University of Salamanca, researchers at Chalmers published a paper in Nature Materials on how device self-heating limits the noise temperature reduction when cooling the InP HEMT transistor towards zero Kelvin. This was highlighted in a press release from both Chalmers and Caltech. Furthermore, the researchers have characterised InP HEMTs at room and cryogenic temperatures by pulsed measurements. The results indicated the role of material defects in the InAlAs-InGaAs-InP heterostructure responsible for the enhanced kink effects in the transistor DC output characteristics under cryogenic conditions.

Schleeh, J. ; Mateos, J. ; Íñiguez-de-la-Torre, I. ; Wadefalk, N. ; Nilsson, P.A. ; Grahn, J. ; and Minnich, A.J., Phonon black-body radiation limit for heat dissipation in electronics (2014). Nature Materials 14, 187–192 (2015); DOI:10.1038/nmat4126.

More information: www.chalmers.se/en/departments/mc2/news/Pages/Noise-in-a-microwave-amplifier-is-limited-by-quantum-particles-of-heat.aspx



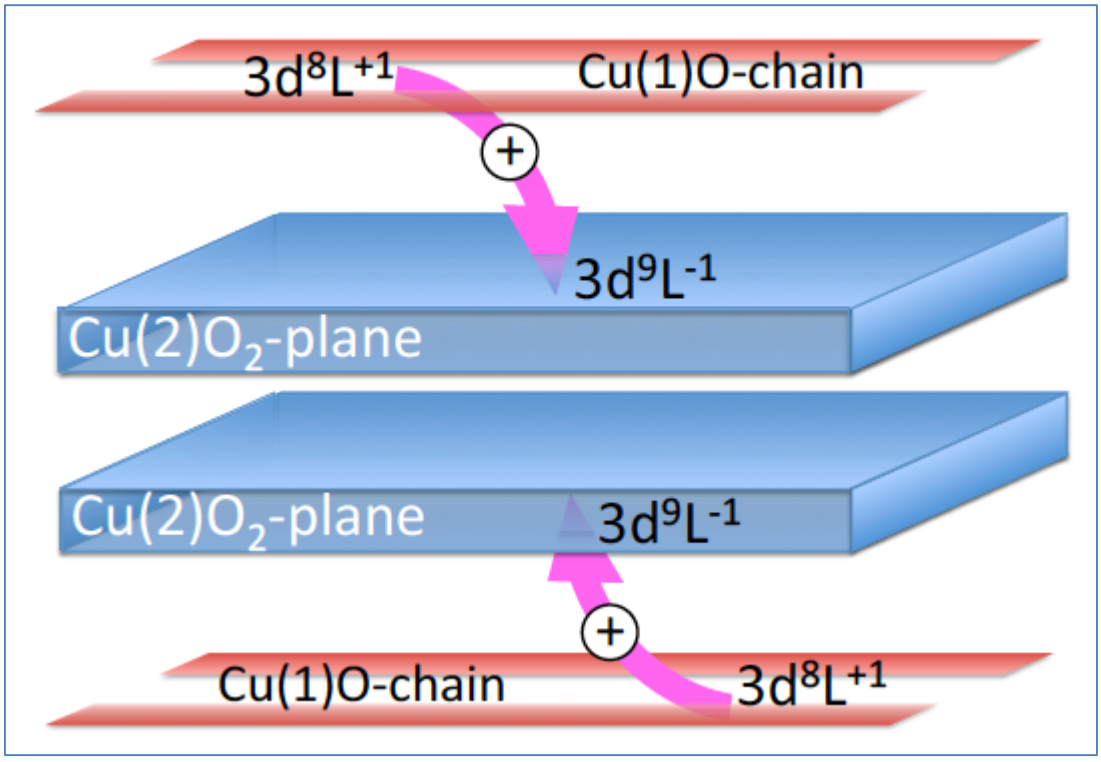
Artistic cross-section of an InP HEMT transistor showing electrons dissipating heat under the gate. Image: Lisa Kinnerud and Moa Carlsson, Krantz NanoArt.

New evidences for self-doping in cuprate superconductors
Materials Researchers at Linköping University, Uppsala University, and Chalmers University of Technology, in collaboration with researchers at the Swiss Light Source (SLS), the Paul Scherrer Institute, investigated high-temperature superconductor, YBa2Cu3O7-x (YBCO), using advanced X-ray spectroscopy. YBCO is a cuprate ceramic material that becomes superconducting when it is cooled down below -183 °C. Since the resistance and the power losses are zero in the superconductors, they find many promising applications. Electromagnets in electric motors can be made smaller with stronger magnetic field that gives more power and lower energy consumption. Magnetic levitating trains reach higher speeds by minimizing

friction between wheels and the rails. The ground breaking information about YBCO self-doping challenges the traditional understanding of the mechanism of superconductivity in copper-based high-temperature superconductors based on assumption of constant doping level in the copper oxide planes.

Magnuson, M.; Schmitt, T.; Strocov, V.N.; Schlappa, J.; Kalabukhov, A.S.; and Duda, L-C., Self-doping processes between planes and chains in the metal-to-superconductor transition of YBa2Cu3O6.9 (2014). Scientific Reports 4, 717 (Nature Publishing) (2014); DOI: 10.1038/srep07017.

More information: www.chalmers.se/en/departments/mc2/news/Pages/New-evidences-for-self-doping-in-cuprate-superconductors.aspx

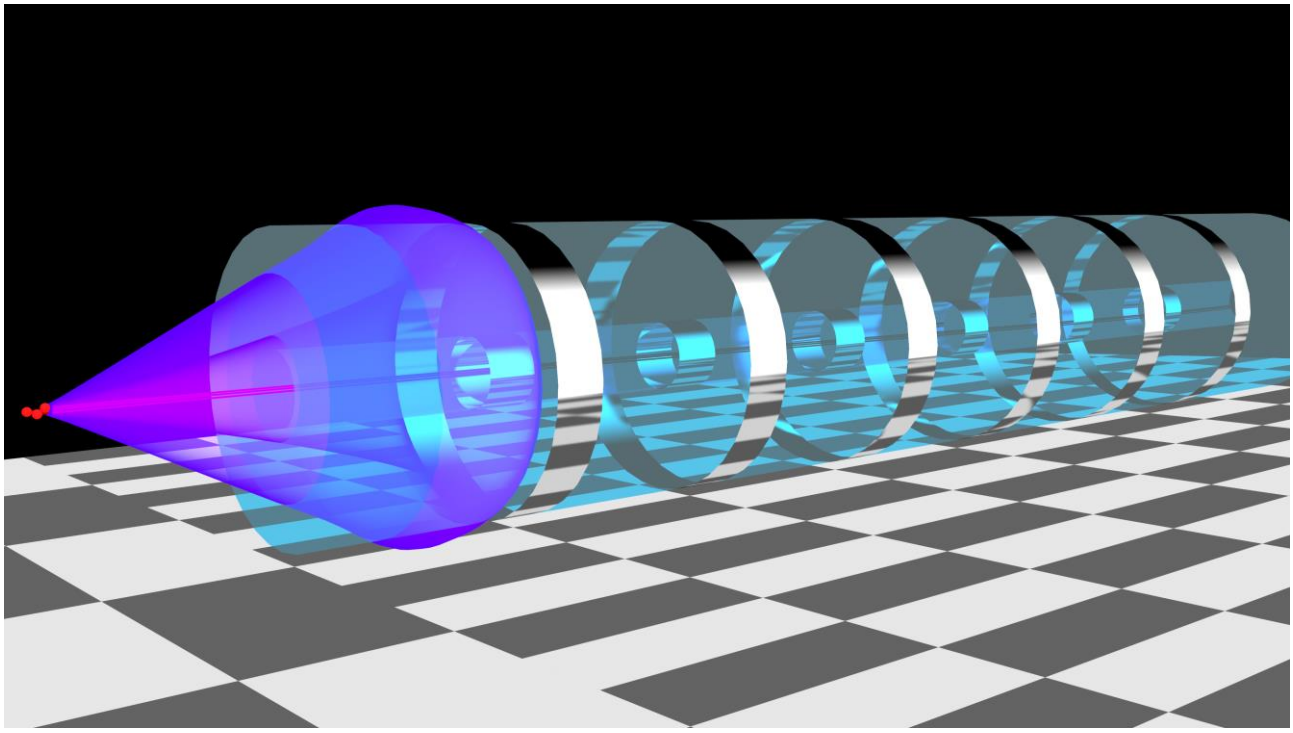


A comparison of XAS data from two different temperatures shows that cooling results in a redistribution of charges between the superconducting copper oxide planes and chains.

Light bending material facilitates the search for new particles
Particle physicists have a hard time identifying all the elementary particles created in their particle accelerators. But now researchers at Chalmers University of Technology have designed a material that makes it much easier to distinguish the particles. Chalmers researcher Philippe Tassin and his colleagues at the Free University of Brussels have designed a material that manipulates the so-called Cherenkov cone so that also particles with high momentum get a distinct light cone angle too. "The result is that even particles with large momentum can be efficiently separated and identified," says Philippe Tassin.

Ginis, V.; Danckaert, J.; Veretennicoff, I. and Tassin, P., Controlling Cherenkov Radiation with Transformation-Optical Metamaterials (2014). Physical Review Letters (2014); DOI: 10.1103/PhysRevLett.113.167402.

More information: www.chalmers.se/en/departments/ap/news/Pages/Pressrelease-Light-bending-material-facilitates-the-search-for-new-particles.aspx



Cherenkov light cone created by particles moving through a metamaterial designed by Chalmers researcher Philippe Tassin and colleagues. The material is constituted by silver cylinders, a few tens of nanometres thick, embedded in a nonconductive material. Image: Vincent Ginis.

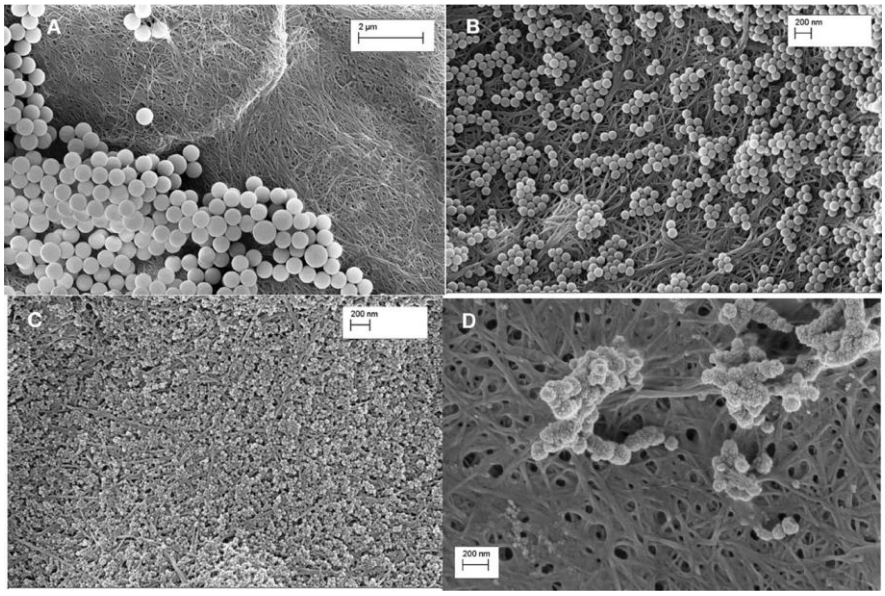
Nano-paper filter can remove viruses
Researchers at the Division of Nanotechnology and Functional Materials, Uppsala University, have developed a paper filter, which can remove virus particles with an efficiency matching that of the best industrial virus filters. Viral contamination of biotechnological products is a serious challenge for production of therapeutic proteins and vaccines, but because of the small size, virus removal is a non-trivial task. Previously described virus removal paper filters relied heavily on interception of viruses via electrostatic interactions, which are sensitive to pH and

salt concentrations, whereas the virus removal filters made from synthetic polymers and which rely on size-exclusion are produced through tedious multistep phase-inversion processing involving hazardous solvents and rigorous pore annealing processing. The new filter consists of 100 percent high purity cellulose nanofibers, directly derived from nature. Cellulose is one of the most common materials to produce various types of filters because it is inexpensive, disposable, inert and non-toxic. It is also mechanically strong, hydrophyllic, stable in a wide range of pH, and can withstand sterilization e.g. by autoclaving. Normal filter paper, used for chemistry, has too large pores to remove viruses. As a result of a decade long research on the properties of high surface area nanocellulose materials, the scientists have been able to tailor the pore size distribution of their paper precisely in the range desirable for virus filtration.

Metreveli, G.; Wågberg, L.; Emmoth, E.; Belák, S.; Strømme, M.; and Mihranyan, A., A Size-Exclusion Nanocellulose Filter Paper for Virus Removal (2014). Advanced Healthcare Materials, 3: 1546–1550 (2014); DOI: 10.1002/adhm.201300641.

World record for CIGS cells

Solibro Research, in collaboration with the solar cell group in the Myfab-Ångström laboratory, set a new world record for CIGS cells in 2014. Using a new lift-off process, the contacts were made to cover a very small area and the cell efficiency reached 21 %. This record has later been beaten, but only with a cell with smaller area.



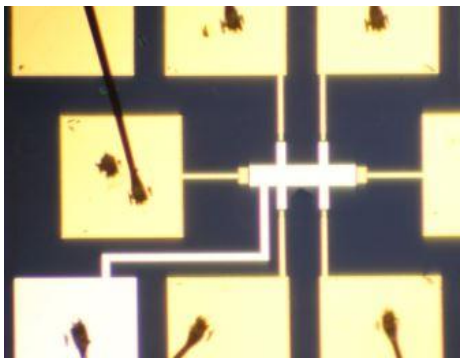
SEM images of PS latex beads and SIV particles following filtration on Cladophora cellulose membrane: a) 500 nm beads; b) 100 nm beads; c) 30 nm beads; and d) SIV particles.

Graphene as a Diffusion Barrier in Galinstan-Solid Metal Contacts
Liquid alloy GaInSn remains its fluid form in a very wide temperature range and is considered a promising material as contact, interconnect and wiring in soft and stretchable electronic systems. However, the compatibility issue of GaInSn with a variety of materials needs to be addressed. Researchers at the Ångström Laboratory have demonstrated a viable solution with graphene as the diffusion barrier to the challenge.

Ahlberg, P. ; Seung Hee, J. ; Mingzhi, J. ; Wu, Z. ; Jansson, U. ; Shi-Li, Z. ; and Zhi-Bin, Z., Graphene as a Diffusion Barrier in Galinstan-Solid Metal Contacts (2014). Electron Devices, IEEE Transactions on, vol.61, no.8, pp.2996, 3000 (2014); DOI: 10.1109/TED.2014.2331893.

MOSFET operation in diamond achieved
Researchers at Uppsala University have achieved MOSFET operation in diamond through the development of effective surface gate oxide and passivation layers. Effective surface passivation is required for reproducibility, to reduce the surface leakage and to reduce the concentration of surface trapping centres.

Kovi, K.K.; Majdi, S.; Gabrysch, M.; and Isberg, J., Silicon Oxide Passivation of Single-Crystalline CVD Diamond Evaluated by the Time-of-Flight Technique (2014). ECS Solid State Letters, 3(5): 65-68, 2014; DOI:10.1149/2.004405ssl.
Kovi, K.K.; Majdi, S.; Gabrysch, M.; and Isberg, J., A charge transport study in diamond, surface passivated by high-k dielectric oxides (2014). Applied Physics Letters, 105, 202102 (2014); DOI: 10.1063/1.4901961.

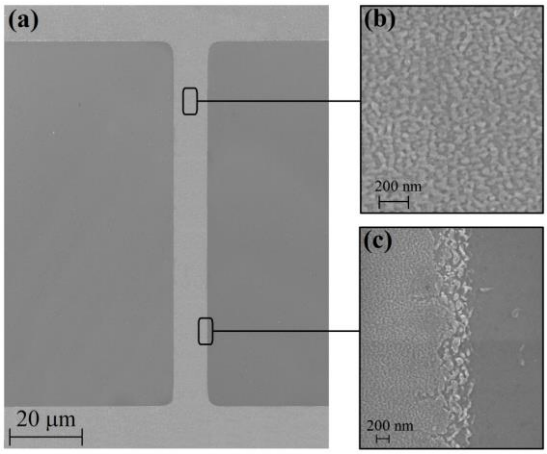


Gated Hall bar structure in diamond for evaluating surface passivation layers

Advanced transfer technique realized wafer-level transferred graphene
Graphene grown by means of chemical vapour deposition (CVD graphene) needs to be transferred onto another substrate for research and application. The conventional transfer process that involves polymer films as a support and baking at elevated temperatures is scalable but has problems in leaving polymeric contaminates on the graphene. A research team at the Ångström Laboratory has advanced the transfer technique and realized wafer-level transferred graphene as clean as that obtained by mechanical cleavage of graphite.

Resistance noise at the metal–insulator transition in thermochromic VO2 films
Thermochromic VO2 thin films, deposited by sputtering, exhibit a strong resistance noise in a region close to the temperature where the semiconductor-metal transition occurs. This noise is a sensitive probe of the dynamic features of percolating semiconducting and metallic-like regions around the transition temperature. Measurements of spontaneous resistivity fluctuations (noise) are technically challenging for VO2 as a consequence of its high temperature coefficient and require small sample volumes in order to avoid excessive heating. Researchers in Solid State Physics at Uppsala University therefore made structures comprising a narrow VO2 micro-bridge by photolithography combined with reactive ion etching (RIE) in the Myfab-Ångström cleanroom facilities.

Topalian, Z.; Li, S. Y.; Niklasson, G. A.; Granqvist, C. G.; and Kish, L. B., Resistance noise at the metal–insulator transition in thermochromic VO2 films (2014). Journal of Applied Physics, 117(2) (2015); DOI: 10.1063/1.4905739.



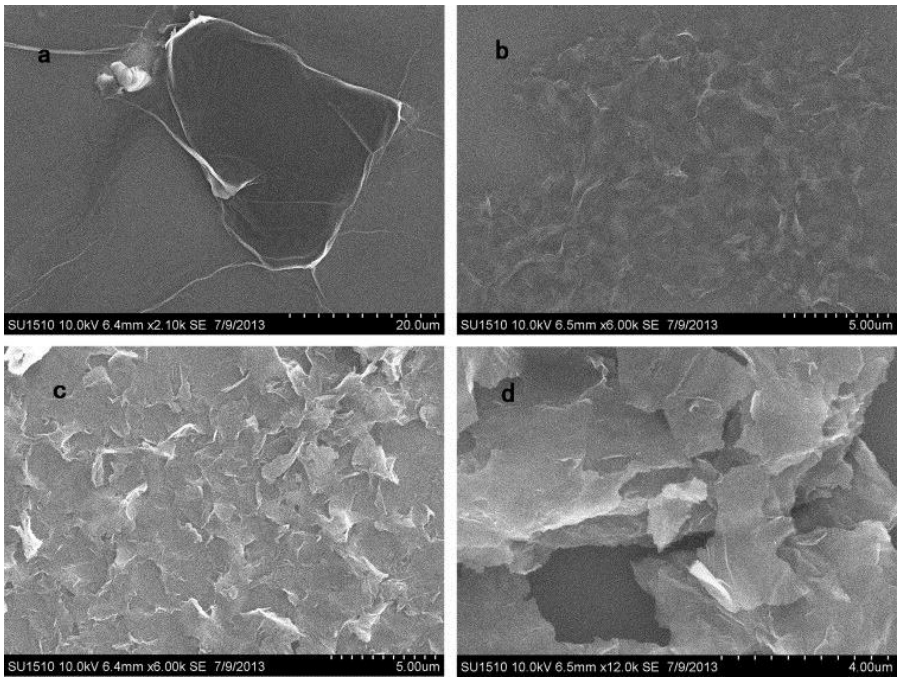
SEM micrographs illustrating the VO2 micro-bridge, which is also shown in Fig. 1(c). Panels (a), (b), and (c) depict the whole structure, a centrally positioned portion of it and an edge part, respectively.

Tuning carrier density across Dirac point in epitaxial graphene on SiC by corona discharge
Researchers at Chalmers have demonstrated reversible control of carrier density control in epitaxial graphene across the Dirac point by depositing static charge on top of a dielectric layer covering the graphene. The static charge was produced by a corona discharge in air. The biggest achieved change in carrier density was an order of magnitude larger than what is possible with a conventional top gate. The method is attractive for applications where graphene with a fixed carrier density is needed, such as quantum metrology, and more generally as a simple method of gating 2DEGs formed at semiconductor interfaces and in topological insulators.

Lartsev, A. ; Yager, T. ; Bergsten, T. et al., Tuning carrier density across Dirac point in epitaxial graphene on SiC by corona discharge (2014). Applied Physics Letters 105 (2014); DOI: 10.1063/1.4892922.

Efficient reduction of graphite oxide by chemical reduction and microwave irradiation
Complete reduction of graphene oxide flakes produced from graphite in a mass-production manner is highly interesting. In a joint research project between the Ångström Laboratory and Fudan University in Shanghai, a reduction procedure that combines the ordinary chemical method with microwave treatment is investigated. The electrical conductivity of a reduced graphene oxide thin film is nearly two orders of magnitude higher than that obtained by the chemical method alone.

Chenyu, W.; Na, Z.; Wei Zhang, D.; Dongping, W.; Zhi-Bin, Z.; and Shi-Li, Z., Efficient reduction and exfoliation of graphite oxide by sequential chemical reduction and microwave irradiation (2014). Synthetic Metals, Volume 194, August 2014, 71-76; DOI: 10.1016/j.synthmet.2014.04.023.

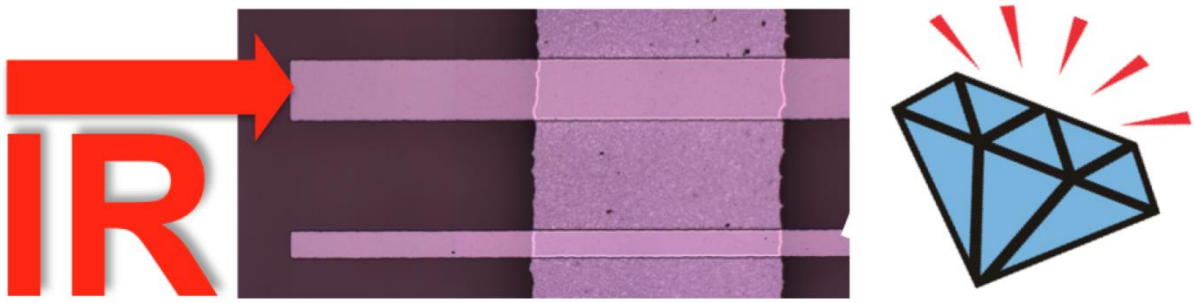


SEM images of (a) GO, (b) RGO_NaBH4, (c) RGO_MW, (d) RGO_NaBH4 + MW.

Thin-Film Diamond Mid-Infrared Waveguides for Advanced Chemical Sensors/Biosensors
The first thin-film diamond strip waveguide (DSWG) suitable for advanced chemical sensing/biosensing has been demonstrated by researchers at Dep. Engineering Sciences and the Uppsala University spin-off company Molecular Fingerprint AB in collaboration with researchers at Ulm University in Germany. The sensing system was fabricated at Myfab-Ångström in Uppsala and is composed of thin diamond films grown on surface-passivated Si wafers via chemical vapour deposition and microstructured using inductively coupled plasma etching, serving as photonic waveguides for radiation emitted by a broadly tuneable quantum cascade laser (tQCL) in the spectral regime of 5.78–6.35 μm (1570–1730 cm-1). The characterization of the free-standing diamond waveguides reveals excellent transmission properties across a broad MIR band. As a proof of concept, the detection of acetone in D2O via evanescent field absorption is demonstrated achieving a limit of detection (LOD) as low as 200 pL, which indicates a significant sensitivity improvement compared to conventional MIR slab/strip waveguides reported to date, and on par or even better than state-of-the-art planar

GaAs WGs. Providing characteristic absorption features within the tuning range of the tQCL, studies using anisaldehyde as an analyte further corroborate the potential of tQCL-DSWG-based chemical sensors/biosensors.

Xiaofeng, W.; Karlsson, M.; Forsberg, P.; Sieger, M.; Nikolajeff, F.; Österlund, L.; and Mizaikoff, B., Diamonds Are a Spectroscopist's Best Friend: Thin-Film Diamond Mid-Infrared Waveguides for Advanced Chemical Sensors/Biosensors (2014). Analytical Chemistry 2014, 86 (16), 8136-8141 (2014); DOI: 10.1021/ac5011475.

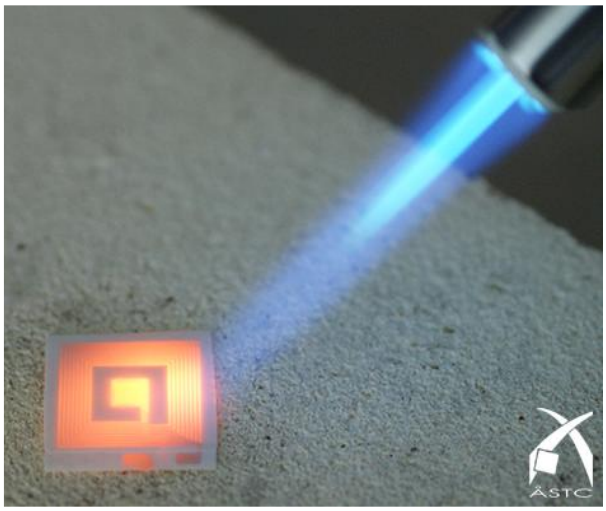


Electrical properties of Ag/Ta and Ag/TaN thin-films

Wide band gap (WBG) materials and devices have been the subject of several successful Swedish research projects. The work so far has mainly concentrated on those material properties that give WBG devices a far better performance than silicon counterparts under similar operating conditions. Although these devices are eminently suited for harsh conditions, the applications are presently limited by the metallurgical stability of the metallization. A research team at the Ångström Laboratory has therefore been investigating if a metallization scheme based on Ag or Cu, combined with barrier and cap layers of Ta and TaN, can be optimized to provide reliable operation at very high temperatures (> 500 °C). The results indicate that with suitable combinations of Ta and/or TaN cap- and barrier- layers, both metal systems (Ag and Cu) are electrically and morphologically stable up to 700 °C.

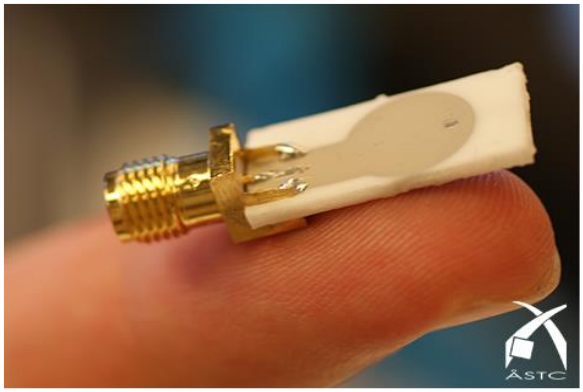
Mardani, S.; Primetzhofer, D.; Liljeholm, L.; Vallin, Ö.; Norström, H.; and Olsson, J., Electrical properties of Ag/Ta and Ag/TaN thin-films (2014). Microelectronic Engineering, Volume 120, 25 May 2014, 257-261; DOI: 10.1016/j.mee.2013.06.002.
Mardani, S.; Vallin, Ö.; Wätjen, J.T.; Norström, H.; Olsson, J.; and Zhang, S-L., Morphological instability of Ag films caused by phase transition in the underlying Ta barrier layer (2014). Applied Physics Letters, vol. 105, 071604 (2014); DOI: 10.1063/1.4893768.
Mardani, S.; Norström, H.; Olsson, J.; Smith, U.; and Zhang, S-L., Influence of tantalum/tantalum-nitride barriers and caps on the high-temperature properties of copper metallization for wide-band gap applications (2015). Microelectronic Engineering, in press, 2015.

Chip-sized ceramic device measures pressure at up to 1000°C
Using a thermomechanically matched conductor and isolator, and wireless powering and reading, a chip-sized ceramic device able to reliably and accurately measure pressure at up to 1000°C has been developed and characterized by researchers at the Ångström Space Technology Centre (ÅSTC) in Uppsala. Besides being world leading in this respect and in hard competition, this project provides a vehicle for moving microtechnology to environments being extremely harsh also in other respects, i.e., erosive and corrosive.



Ceramic pressure sensor with antenna subjected to butane torch.

High-performance RF-based ceramic microplasma generator
A high-performance RF-based ceramic microplasma generator has been successfully realized by an ÅSTC team at the Ångström Laboratory. The device is made in platinum and alumina to minimize ageing from material degeneration and to eliminate the risk of contamination when it serves as a detector in optogalvanic measurements of isotope ratios in subnanogram samples.

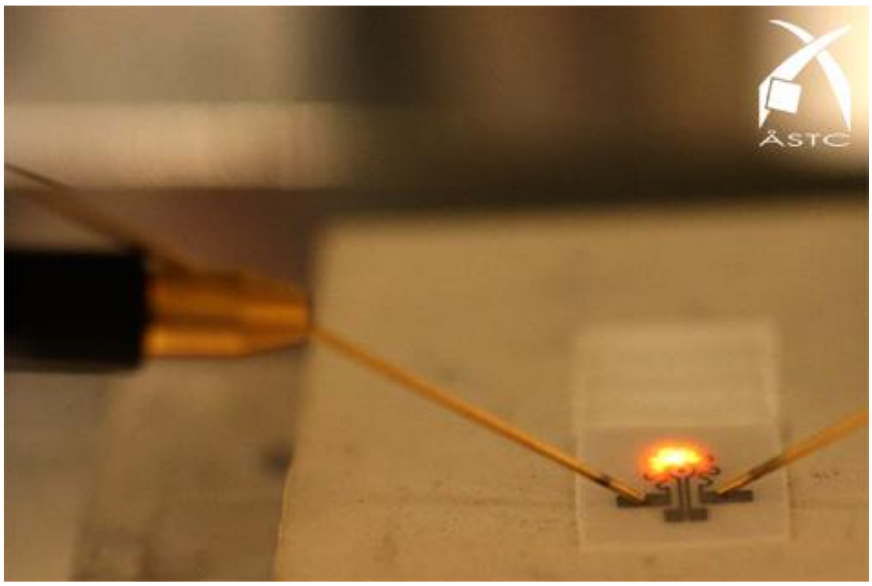


Monolithic alumina plasma source.

Investigation of the storage and release of oxygen in a Cu-Pt element of a high-temperature microcombustor

Intended for self-contained on-chip generation of carbon dioxide from solid organic samples, a microcombustor with integrated oxygen supply has been developed by ÅSTC at Myfab-Ångström, This is a unique microdevice, containing a coated heater able to release enough oxygen at 850°C to burn a couple of micrograms of carbon in its microlitre chamber while being monitored by an integrated temperature sensor.

Khaji, Z. ; Sturesson, P. ; Hjort, K. ; Klintberg, L. ; and Thornell, G., Investigation of the storage and release of oxygen in a Cu-Pt element of a high-temperature microcombustor (2014). Journal of Physics: Conf. Ser. 557 012078 (2014); DOI: 10.1088/1742-6596/557/1/012078.



Resistive heating of the heater pattern using probes.

Ion-gated bipolar amplifier for ion sensing with enhanced signal and improved noise

A new ion-gated bipolar amplifier (IGBA) ion sensor that greatly improves the signal-to-noise ratio has been developed by a team in Solid State Electronics at the Ångström Laboratory. The new sensor device, consists of a modified ion-sensitive field-effect transistor (ISFET) intimately integrated with a vertical bipolar junction transistor for immediate current amplification. With the current non-optimized design, it is already characterized by a 70-fold internal amplification of the ISFET output signal and leads to a 3-fold improvement in signal-to-noise performance compared to using its ISFET reference.

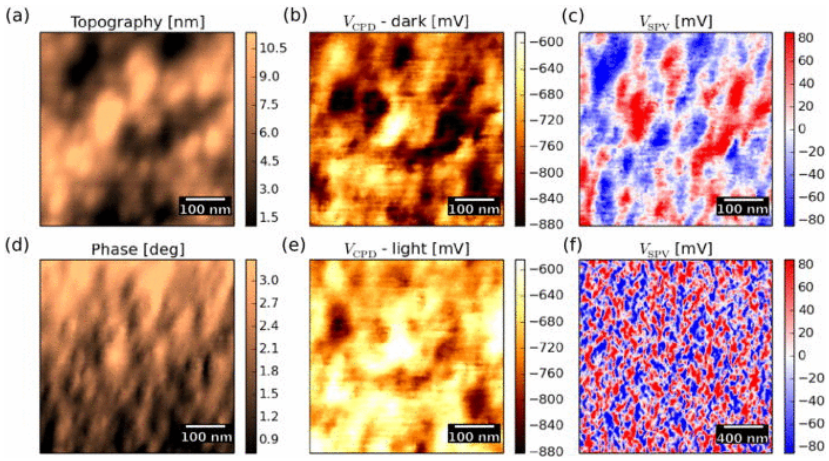
Zhang, D. ; Gao, X. ; Chen, S. ; Norström, H. ; Smith, U. ; Solomon, P. ; Zhang, S-L. ; and Zhang, Z., An ion-gated bipolar amplifier for ion sensing with enhanced signal and improved noise performance (2014). Applied Physics Letters, 105, 082102 (2014); DOI: 10.1063/1.4894240.

Super sensitive Electrostatic Force Microscopy

One of the most popular and useful methods of Electrostatic Force Microscopy is Kelvin Probe Force Microscopy (KPFM), which provides a measurement of the contact potential difference (sometimes referred to as the surface potential). Kelvin Probe Force Microscopy is widely used for advanced imaging of composite polymeric materials, for imaging of the local work function

on the surface of organic photovoltaic materials, and for mapping doping concentrations in electronic devices. Although the technique is useful to investigate electric properties of surfaces at the nanoscale, the signal-to-noise ratio, accuracy, and speed are limited by the inherent measurement technique. Researchers at KTH Royal Institute of Technology presents a completely new technique based on intermodulation (frequency mixing) which allows for a more sensitive force measurement resulting in, shorter imaging times and considerably higher resolution.

Borgani, R. ; Forchheimer, D. ; Bergqvist, J. ; Thoren, P-A. ; Inganäs, O. ; and Haviland D. B., Intermodulation electrostatic force microscopy for imaging surface photo-voltage (2014). Applied Physics Letters 105, 143113 (2014); DOI: 10.1063/1.4897966.



Example of images obtained by super sensitive Electrostatic Force Microscopy, where different domains are clearly visible with size in the order of 50–100 nm.

Improved AFM image contrast on soft-mater by using intermodulation distortion

Imaging soft materials with the AFM is increasingly important for a wide variety of applications, from biology to composite plyometric materials. Researchers at KTH Royal Institute of Technology have developed a quantitative method for determine tip-surface interaction forces, based on the measurement of high-order intermodulation, or frequency mixing. The method generates a wealth of information as the tip scans over the surface. It was shown how this information can be used to drastically increase image contrast and enhance the AFM's ability to discriminate between different mechanical response on heterogeneous surfaces at the nanometer scale.

Forchheimer, D. ; Robert Forchheimer, R. ; and Haviland, D.B., Improving image contrast and material discrimination with nonlinear response in bimodal atomic force microscopy (2014). Nature Communications 6, 6270 (2014); DOI: 10.1038/ncomms7270.

First report on high temperature operation of a fully integrated SiC bipolar opamp

Researchers at KTH Royal Institute of Technology have demonstrated a monolithic, 500C Operational Amplifier in 4H-SiC Bipolar Technology with a closed loop gain of 40 dB and a 3 dB bandwidth of 410 kHz at 500 deg C. This is the first report on high temperature operation of a

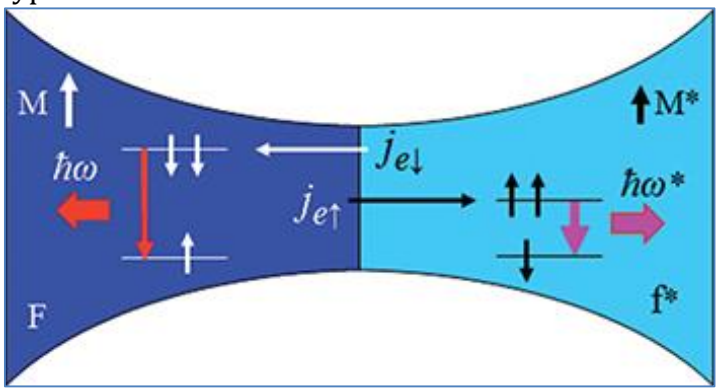
fully integrated SiC bipolar opamp which demonstrates the feasibility of this technology for high temperature analogue integrated circuits.

Hedayati, R. ; Lanni, L. ; Rodriguez, S. ; Malm, B. G. ; Rusu, A. ; and Zetterling, C-M., A Monolithic, 500 degrees C Operational Amplifier in 4H-SiC Bipolar Technology (2014). IEEE Electron Device Letters, Vol. 35, No. 7, 693-695 (2014); DOI: 10.1109/LED.2014.2322335.

More information: www.hotsic.se

First experimental evidence of the Spin Laser

The discoveries of masers and lasers have led to major breakthroughs in science and technology. Later important developments include compact semiconductor lasers for visible to near-infrared and quantum cascade lasers for far-infrared to THz radiation. Researchers at KTH Royal Institute of Technology have proposed a new principle of stimulated spin-flip photon emission in metallic ferromagnets, originating from the electron-photon interaction, with strength proportional to the large exchange energy in the ferromagnet, exceeding by orders of magnitude typical Zeeman energies for electrons in external magnetic fields. A giant lasing effect is expected if the spin-population inversion is achieved by spin injection in a suitable nanodevice, such as a photon-resonator–integrated magnetic point contact array. The expected frequency range is dictated by the exchange splitting in the active ferromagnetic region, typically 10–100THz, and the optical gain is expected to exceed that of conventional compact semiconductor lasers by 3 to 4 orders of magnitude due to the vastly higher carrier density in metals. If successful, such metal-based spin-flip lasers should be a breakthrough in the field of spin-photo-electronics. Here the researchers show the first experimental evidence of this new type of solid state laser.



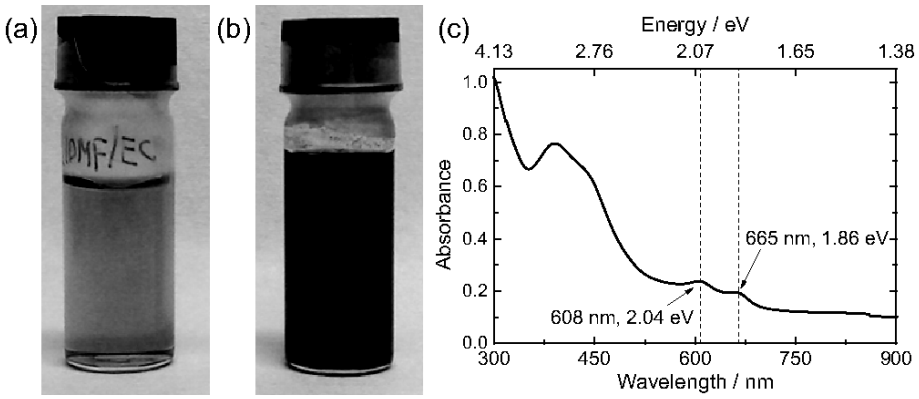
Schematic of spin-flip photon emission in a spin-majority/minority ferromagnetic point contact, for negative- and positive-bias polarity, carrying predominantly spin-down and spin-down electron currents. The arrows of different colours and thickness illustrate the expected different radiation frequency and intensity in the two cases.

Development of inkjet printing technology for MoS2

Researchers at KTH Royal Institute of Technology have developed a simple and efficient inkjet printing technology for molybdenum disulfide (MoS2), which is one of the most attractive two-dimensional layered materials. The technology efficiency facilitates the integration of printed MoS2 patterns with other components (such as electrodes), and hence allows fabricating

various functional devices, including thin film transistors, photoluminescence patterns, and photodetectors, in a simple, massive and cost-effective manner while retains the unique properties of MoS2.

Jiantong, L. ; Maziar M. N. ; Vaziri, S. ; Lemme, M. C. ; and Östling, M., Inkjet Printing of MoS2 (2014). Advanced Functional Materials, Vol. 24, No. 41, pp. 6524-6531 (2014); DOI: 10.1002/adfm.201400984.



MoS2 inks. a) Photograph of the MoS2/DMF dispersion before distillation. The MoS2 nanosheets have been stabilized by EC. b) Photograph of the final MoS2/terpineol ink. As compared with the initial MoS2/DMF dispersion in (a), the MoS2/terpineol ink is first concentrated by 20 times via distillation and then tailored by ethanol at the volume ratio of terpineol:ethanol = 3:1. c) Absorbance spectra for the MoS2 ink in (b) diluted by 20 times with terpineol.

Fabrication and Design of 10 kV PiN Diodes Using On-axis 4H-SiC

10 kV PiN diodes using on-axis 4H-SiC were designed, fabricated, and measured by researchers at KTH Royal Institute of Technology. A lifetime enhancement procedure was done by carbon implantation followed by high temperature annealing to increase lifetime to above 2 µs. The device simulation software Sentaurus TCAD has been used in order to optimize the diode. All fabricated diodes are fully functional and have a VF of 3.3 V at 100 A/cm2 at 25°C, which was decreased to 3.0 V at 300°C.

Salemi, A. ; Buono, B. ; Hallén, A. ; Ul Hassan, J. ; Bergman, P. ; Zetterling, C-M. ; and Östling, M., Fabrication and Design of 10 kV PiN Diodes Using On-axis 4H-SiC. Materials Science Forum (2014); 778-780, 836 /www.scientific.net/MSF.778-780.836.

Germanium nanowire transistor for sequential 3D integration

In this project, funded by the Swedish Foundation for Strategic Research (SSF) 2014-2019, KTH Royal Institute of Technology and Uppsala University performs research to enable technology for monolithic 3D integrated circuits. A cross-wise utilization between Electrum Laboratory and Ångström Laboratory is conducted in several areas such as e-beam lithography, conformal PVD and ion implantation at UU and RIE, PECVD, I-line stepper lithography and Ge growth at KTH.

9. The infrastructure's significance to direct societal interests

Myfabs premises are all openly available to a broad range of users from academia and industry. Students from the master programs can have access to the cleanrooms during their undergraduate studies and diploma projects, under the supervision of their supervisors and with the assistance of the cleanroom staff. This opportunity to gain relevant training in a real cleanroom environment is rather rare in the rest of the world, where the requirement typically is that you have started as a PhD student or have similar experience.

Myfab actively informs the public of the possibilities which micro and nanotechnology gives society in a popular form. Outreach activities include about 2500 visitors annually to Myfab cleanrooms. In particular, the guided tours to the cleanroom for students and the public during the International Science festival in Gothenburg and the Future Friday event at KTH in Kista are very popular. The guided tours to the cleanroom are probably the activities which are the most fully booked of them all at both these events. The educational aspect is important for society. Students and researchers educated in micro/nanotechnology within Myfab, who later proceed to private enterprises or public organisations, constitute efficient communicators of knowledge during many years. These persons are also important for Myfabs network of experts and are competent procurers of projects etc.

10. The infrastructure's significance to trade, industry and other commercial interests

Myfab was established to provide a research infrastructure that would help researchers to solve the grand challenges of the world today – climate change, energy supply, aging population, diseases etc. Technology on the micro and nano scale is very important in today's electronics, automotive industry, cosmetics, hygiene, clothes, household products, food, sports and toys. Myfab is a supplier of competence needed to increase the competitiveness for Swedish industry, create jobs, improve healthcare and by making better use of the world's resources. Research in these areas is fundamental also to provide state-of-the-art education, attract the best students and so on.

About 30 spin-off companies have been created from research activities within Myfab during the last five years. Spin-off companies from Myfab have a turnover of more than 500 MSEK. Myfab has served about 120 companies during the last 5-year period with cleanroom access, process service etc. Several of these companies have special agreements and rent cleanroom space and install their own equipment in the cleanrooms. Myfab supports a scientific approach to understand and avoid possible safety risks related to nanotechnology.

It is of central importance for Swedish industry to have access to highly educated staff within the growing field of nanotechnology. Such an education must be experimentally hardware-oriented and here, Myfab's flexibility suits the purpose very well.

ANNEX

A. Key numbers for Myfab 2014 - from Myfab LIMS

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

Annex A:

Key numbers for Myfab 2014 - from Myfab LIMS

	Statistics for 2014				Historic values for MyFab			
	Electrum	MSL	NFL	MyFab	2013	2012	2011	2010
Number of:								
Users with access:	394	351	433	**1178**	*1128*	*1094*	*1040*	*982*
Active users:	223	235	206	**664**	*647*	*630*	*622*	*573*
Female active users:	44	68	46	**158**	*142*	*146*	*145*	*127*
Gender balance, active users:	20%	29%	22%	**24%**	*22%*	*23%*	*23%*	*22%*
Number of active users from:								
Universities:	165	199	191	**555**	*536*	*525*	*512*	*455*
Institutes:	21	1	0	**22**	*24*	*26*	*33*	*35*
Commercial:	37	35	15	**87**	*86*	*79*	*77*	*83*
Number of companies with own personnel:	17	21	8	**46**	*50*	*44*	*43*	*38*
Number of booked hours:	40789	26267	56100	**123156**	*131923*	*137402*	*134542*	*126070*
Booked hours from:								
Universities:	24560	24557	54040	**103156**	*110189*	*112550*	*110513*	*103706*
Institutes:	11592	44	0	**11636**	*13146*	*17346*	*16546*	*16054*
Commercial:	4638	1666	2060	**8363**	*8586*	*7506*	*7484*	*6310*
Number of tools:	218	190	195	**603**	*586*	*568*	*532*	*461*
Booked tools:	102	71	144	**317**	*329*	*330*	*328*	*291*

Chalmers MC2 Nanofabrication Laboratory – 2014

1. S. Abay, D. Persson, H. Nilsson, F. Wu, H. Xu, M. Fogelström, V. Shumeiko och P. Delsing, "Charge transport in InAs nanowire Josephson junctions", *Physical Review B. Condensed Matter and Materials Physics* 89 (2014): 214508. doi: 10.1103/PhysRevB.89.214508.
2. D. Adolph och T. Ive, "Nucleation and epitaxial growth of ZnO on GaN(0 0 0 1)", *Applied Surface Science* 307 (2014): 438-443. doi: 10.1016/j.apsusc.2014.04.051.
3. F. Ahlers, J. Kučera, W. Poirier, B. Jeanneret, A. Satrapinski, A. Tzalenchuk, P. Vrabček, T. Bergsten, C. Hwang, R. Yakimova och S. Kubatkin, "The EMRP project GraphOhm- Towards quantum resistance metrology based on graphene" (CPEM Digest. 29th Conference on Precision Electromagnetic Measurements, CPEM 2014; Rio de Janeiro; Brazil, 2014.
4. M. Andersson, A. Vorobiev, S. Gevorgian och J. Stake, "Comparison of carrier scattering mechanisms in chemical vapor deposited graphene on fused silica and strontium titanite substrates" (Graphene Week 2014), 2014.
5. M. Andersson, A. Vorobiev, S. Gevorgian och J. Stake, "Extraction of carrier transport properties in graphene from microwave measurements " (European Microwave Conference (EuMC), 2014 44th), 2014. doi: 10.1109/EuMC.2014.6986444.
6. R. Arpaia, M. Ejrnaes, L. Parlato, R. Cristiano, M. Arzeo, T. Bauch, S. Nawaz, F. Tafuri, G. Pepe och F. Lombardi, "Highly homogeneous YBCO/LSMO nanowires for photoresponse experiments", *Superconductor Science & Technology* 27 (4) (2014
7. R. Arpaia, D. Golubev, R. Baghdadi, M. Arzeo, G. Kunakova, S. Charpentier, S. Nawaz, F. Lombardi och T. Bauch, "Resistive state triggered by vortex entry in YBa2Cu3O7-delta nanostructures", *Physica C-Superconductivity and Its Applications* 506 (2014)
8. R. Arpaia, M. Arzeo, S. Nawaz, S. Charpentier, F. Lombardi och T. Bauch, "Ultra low noise YBa2Cu3O7-delta nano superconducting quantum interference devices implementing nanowires", *Applied Physics Letters* 104 (7) (2014)
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Licentiate thesis

1. M. Andersson, *Microwave characterisation of electrodes and field effect transistors based on graphene*
2. R. Arpaia, *YBCO nanowires for ultrasensitive magnetic flux detectors and optical applications*
3. P. Aurino, *Nano-patterning of two-dimensional electron gas at the interface between SrTiO3 and LaAlO3*
4. R. Dahlbäck, *HBV frequency multiplier 2D arrays and application*
5. Hammar, *Optical Analysis and Characterisation of the Climate Research Instrument STEAMR*
6. R. Ogier, *Plasmonics with a Twist*
7. S. Syrenova, *Nanoplasmonic Spectroscopy of Single Nanoparticles Tracking Size and Shape Effects in Pd Hydride Formation*

PhD Thesis

1. S. Bevilacqua, *Study of MgB2 and YBa2Cu3O7-x Microbolometers for THz Sensing*

Applications

2. X. Luo, *Characterization of nano-scale materials for interconnect and thermal dissipation application in electronics packaging*
3. A. Pourkabirian, *Probing quantum and classical noise in nano circuits*
4. B. Zandén, *Functional Fiber Based Materials for Microsystem Applications*
5. S. de Graaf, *Fractal superconducting resonators for the interrogation of two-level systems*
6. F. Mazzotta, *Probing nanoscale phenomena with nanoplasmonic sensors*
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