

Swedish Graphene Forum

2023



The power of deeptech

Sweden's leading experts and companies in graphene and other 2D materials experienced Swedish Graphene Forum 2023 at Medicon Village in Lund.

80 attendees, over 30 presentations, a thrilling pitch-finale of the Innovation Competition and an eminent study visit at Alfa Laval. We saw the power of deeptech.

The forum was filled with collaboration and entrepreneurship, cutting-edge research, prototypes and sustainable results. Key-note speaker Anne Lidgard, director at Vinnova, summarized it from the stage.

– You guys really contribute to our Swedish competitiveness in a very exciting area, she said.

SIO
GRAFEN





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Front page: Jon Wingborg congratulates Innovation Competition winners Kinga Grenda from Adsorbi and Savannah Zacharias from Glenntex. Photo: Peter Kroon.

Evidence of progress

Swedish Graphene Forum is Sweden's largest annual conference for graphene and other 2D materials. This year, the community showed the multifunctionality of the materials and an increasing pace towards market. Overall, an intense experience in Lund.

The event is an open arena, where industry and academia come together to share innovations. Always buzzing with discussions and networking. This year's project results are presented in this magazine and the vast broadness of this growing part of Swedish industry is no joke.

Read about graphene and related materials in batteries, lubricants, wood fibre composites, medtech devices, coatings, photo detectors, rubbers, computer cooling, airplane de-icing and more. Also, advances are made in industry infrastructure as testbeds, standardization, LCA-analysis, health issues and so on. It is impressive.

Anne Lidgard from Vinnova expressed it well in her closing comments at Medicon Village.

– This is a very exciting area of new and advanced materials and your knowledge and entrepreneurship have an important role to play, she said.

Also, the progress of small companies was plain for anyone to see. Which is utterly important to reach a more sustainable future with the help of 2D materials.

Elisabeth Sagström-Bäck, Programme Director of SIO Grafen, said from the stage.

– The development of these startups, growing to scaleups and beyond, is essential for our 2DM eco system. It shows the belief that entrepreneurs and investors have in our Swedish deeptech graphene market and creates job opportunities, she said.

**Swedish Graphene Forum 2024 will take place in Luleå.
You are hereby invited.**

The Programme Office of SIO Grafen





A fantastic niche application

Graphene is the key ingredient to make a perfect measurement system for resistance standards.

– This is very attractive for the industry, says Hans He from RISE.

Graphene has many amazing and unique properties. Although most graphene products on the market are great, it is so far rare that they are revolutionizing.

One exciting exception is the use of graphene to define the value of electrical resistance, ohm. All SI units are nowadays defined by physical constants and not by, for example, the length of a stick in Paris.

– The value for electrical resistance is now defined by the properties of graphene and it can be measured with extreme accuracy. This obviously puts high demands on the properties of the graphene, and the only supplier that can achieve this in Europe is the Swedish company Graphensic, explains Hans He.

RISE and Graphensic have worked together in several earlier projects and have for example managed to increase the temperature range and reduce the required magnetic fields. This allows significantly more manageable equipment to be used. They are also working together with Measurements International in this project.

– There is one drawback with using graphene. The value of the resistance you get is 12.9 k Ω , which makes calibration tricky. We are now working on connecting an array of graphene in series and in parallel in order to allow for calibration samples with 1, 10, 100 Ω etc. This will make it much easier to use these devices in industry, says Hans He.

Project partner facts

Graphensic is a Swedish company that produces high-quality graphene material.

RISE is Sweden's leading research institute for metrological applications of graphene.

Measurements International is a Canadian company renowned for precision measurement instruments and systems.



Hans He, researcher from RISE.

Graphene coating treatment for aluminum batteries

Aluminum batteries are considered as an alternative to lithium-ion batteries for numerous reasons, and coating graphene on the surface of aluminum make it even more interesting for the future battery megamarket.

In this project, Mid Sweden University and 2D Fab aim to modify the surface of the aluminum anode by applying a thin coating of graphene on the Al-surface. The Al-matrix and graphene would produce a galvanic corrosion system, which facilitates removing the inert oxide film. Moreover, the graphene film will protect the fresh Al-surface from corrosion products that are produced on the Al-side in contact with the electrolyte.

– There are some challenges with aluminum batteries, where graphene can solve some. Our hypothesis is that the graphene film in this way will improve the electro-chemical performance of the aluminium battery, says researcher Shahrzad Arshadirastabi, Mid Sweden University.

In general, optimizing the native passivating oxide layer in Al-surface metals is a serious issue in all Al-based batteries. Here, they used a spin coating technique to coat a very thin layer of graphene on the Al-surface.

– After this pre-study we will continue to work on a more efficient spin coating, battery cell assembly, and the electro-chemical evaluation, says Shahrzad Arshadirastabi.



*Shahrzad Arshadirastabi,
Mid Sweden University*



*Martin Lovmar,
Wellspect*

Antibacterial surfaces

It's now been several years since Wellspect together with Chalmers discovered that graphene really can be used to create antibacterial surfaces. They have had several projects which have proven the effect, but it has been more challenging to find a production method that works at large scale.

– We are working together with Mid Sweden University on a laser-assisted production process in this project. The initial results are promising and we still have all the advantages with the mechanical antibacterial effect of vertical graphene flakes. A medical device with this surface has the potential to reduce risk for infection with a low risk of resistance development, no indication of toxicity and a relatively simple product registration process, says Martin Lovmar from Wellspect.

Cement-based coating

Chalmers, Smart High Tech, RISE, Akademiska Hus, Göteborgs Stad and Lanark have collaborated regarding a 2D material cement-based coating. In the coating they added low dosage of hexagonal boron nitride, flakes and fibres, and the hope was at first hand for infrastructure constructions to provide better adhesion and better resistance to chloride penetration and lower carbonation without altering the colour of the paint – and then compare it to existing commercial paint systems.

– The adhesion improves with boron nitride, but the resistance to chloride penetration deteriorated, carbonation small effect, fluidity and bending properties are equivalent. The colour from boron nitride was not all white, but partly yellow, so we will go back to graphene inclusion. This formula is not adequate for infrastructure but with good adhesion, permeability, and UV stability it is useful for concrete buildings and walls, also for interior and underground walls. says Lars Nilsson.

There is a coated demonstration wall at Chalmers campus in Gothenburg.



Electrically conductive adhesives

Professor Reverant Crispin from Linköping university immediately gets the attention from the audience with his opening statement regarding air conditioning.

– Ten percent of the electricity bill in the world is for air conditioning, and we are reducing this by developing local cooling systems instead of cooling large empty rooms, says Reverant Crispin.

Linköping university, ParsNord, IMRA Europe and RISE are using MXenes to enhance the electrical conductivity of adhesives, which is required for new thermoelectric cooling systems to function. This for example allows the cooling systems to be flexible and thereby makes them functional in many more situations, such as in clothing.

The project “2D-electrically conductive adhesive for low-cost flexible electronics and thermoelectrics” covers many of SIO Grafen’s area of strengths such as manufacturing, composites, energy and electronics.



Carmen Cobo Sanchez, RISE.

Graphene composites for rubber

RISE, Trelleborg and 2D fab aim to increase solvent resistance and electrical conductivity of rubber in fuel tanks. By adding graphene, graphene oxide (GO) and/or reduced GO, they want to make a tortuous path for the fuel to go through and add more inert material for increasing chemical stability.

– Our next step is to compare lab scale dispersion solvent mixing with an industrially relevant masterbatch, says Carmen Cobo Sanchez, researcher from RISE.

The project started in June 2023 and ends during 2024, with upcoming results going from lab to industry.



Omid Habibpour, Chalmers.

Promising photodetectors

The digital transformation across all industries drives the demand for higher capacity and lower power consumption for all telecommunication. Photonic integrated circuits allow for these improvements, but a high-performance photodetector at 1550 nm, the most widely used wavelength, which also is CMOS compatible is needed.

– We solve this with a concept based on a graphene-silicon Schottky diode. We have very promising results from simulations and have fabricated most of the device. In the last few months of the project we will finalise the fabrication and measure the experimental performance, says Omid Habibpour from Chalmers who collaborates with the company Gotmic in the project.

"Very impressive"

Anne Lidgard, director at Vinnova, joined Swedish Graphene Forum in Lund. The deeptech expert liked what she saw.

Being at the Swedish innovation agency since 2006, Anne Lidgard knows her way around startups, entrepreneurs, and business opportunities. As a former manager of Vinnova's office in Silicon Valley – Nordic Innovation House, Anne Lidgard has helped Swedish startups and companies to build contacts in one of the world's largest innovation hubs.

An exciting area

Now, she touched ground with the Swedish eco-system of graphene and other 2D materials.

- Having 13 startups in this area is incredible, very impressive, she said from the stage during her keynote speech.
- What you all do is really smack in the middle of what we like to fund regarding deeptech. This is a very exciting area of new and advanced materials and your knowledge and entrepreneurship have an important role to play, Anne Lidgard said.

Challenges ahead

On behalf of the government, Vinnova together with the Swedish Agency for Economic and Regional Growth have developed proposals to improve the conditions for research-intensive startup companies. The report was finalized early 2023.

Anne Lidgard worked with the government assignment at Vinnova and pointed out some of the challenges ahead for Swedish deeptech companies.

One is about the entrepreneurial driving force needed to transform research into companies and continue developing them internationally.

- We have plenty of knowledge and research, but it is the entrepreneur who is the fuel, said Anne Lidgard.

Keep going forward

Lidgard stayed during the lunch-to-lunch conference, saw the presentations and the pitch-finales of the SIO Grafen Innovation Competition.

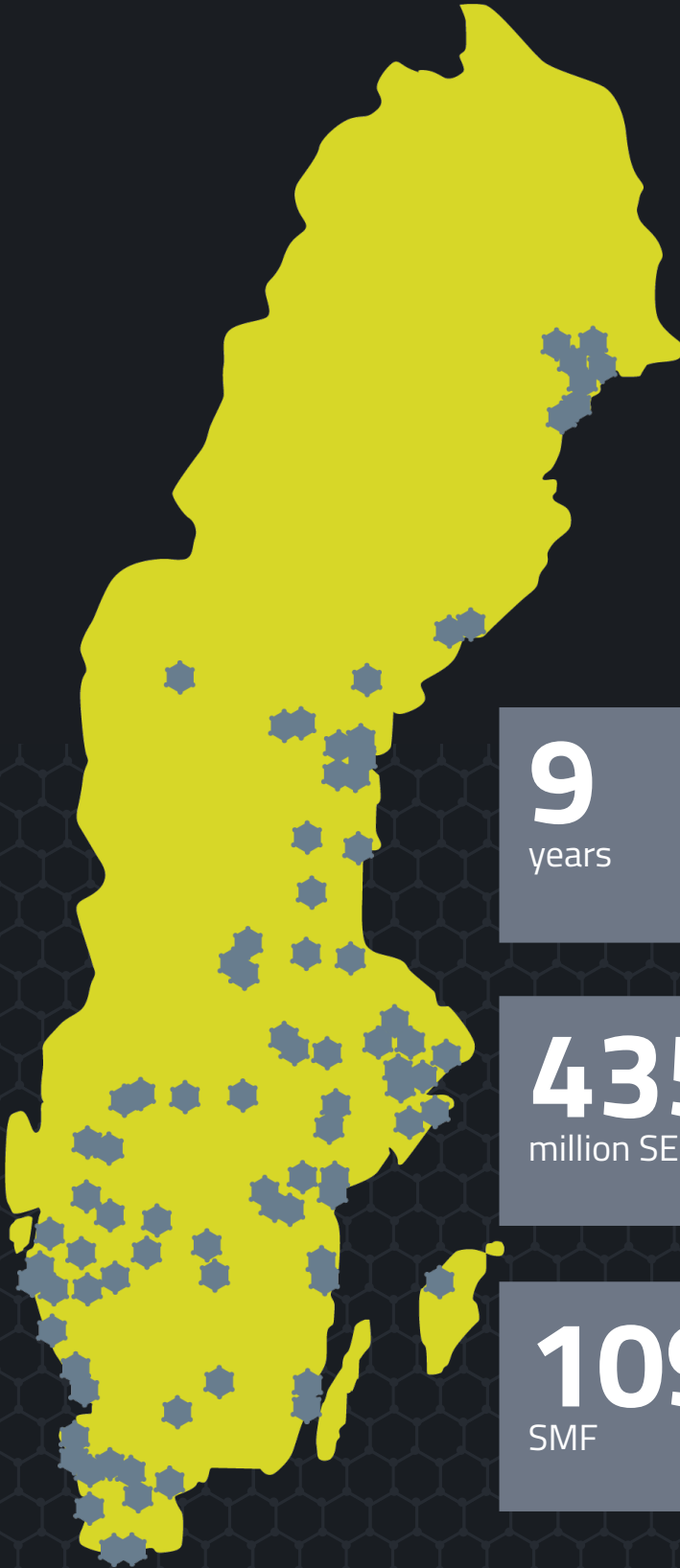
- I was thrilled to hear the presentations. You guys really contribute to our Swedish competitiveness in a very exciting area. Keep up the good work!



Deeptech expert Anne Lidgard on stage.



It's a fact!



9
years

228
organisations

435
million SEK

25
international
organisations

109
SMF

201
projects



We know how to make business of 2D materials

SIO Grafen's Programme Office is always willing to guide you through the Swedish eco-system of graphene and other 2D materials. We are happy to share our expertise and help you get started, match you with the right partners, or develop your idea, within this growing field of business.

Call us today!

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Worthy winners

The young graphene companies Adsorbi and Glenntex won the SIO Grafen Innovation Competition 2023 and share SEK 600,000.

– Two winners of exceptional quality, says competition leader Jon Wingborg.

At Swedish Graphene Forum in Lund, the winners Adsorbi and Glenntex were presented in front of an enthusiastic crowd inside Medicon Village.

– We have seen six phenomenal finalists with ground-breaking innovations in graphene and 2D materials. This paves the way for a bright future with exciting new products, says Jon Wingborg.

Purifies the air

Adsorbi has a patented material that can be used wherever air pollution is a problem – in air filters, products that remove bad odors and at museums to protect works of art.

– This award means a lot to us and will really help us move forward in our work to develop a new type of product with graphene, says Kinga Grenda from Adsorbi.

Recycles plastic

Glenntex takes advantage of graphene in a slightly different way. The company uses the 2D material to simplify and improve sustainable plastic recycling.

– We are very happy for the award and will use the funds in the best way possible to meet challenges, in our important field of work, says Savannah Zacharias from Glenntex.

From Chalmers

SIO Grafen's innovation competition took place in the summer and autumn of 2023 and culminated with the pitch-finale and award ceremony at Swedish Graphene Forum. The winners, who both originates from research at Chalmers in Gothenburg, won SEK 300,000 each.



Facts

Two winners

Adsorbi and Glenntex

Six finalists

Jan Nordin from Grafoam, Govin Induchoodan from Glenntex, Kinga Grenda from Adsorbi, André Persson from Chalmers, Jun Zhao from Luleå University of Technology, Viney Ghai from Chalmers.

The jury

Mala Valroy from Industrifonden, Elisabeth Sagström-Bäck from SIO Grafen, Torkel Nord Björneman from Graphmatech, Michail Pagounis from Business Sweden, Anna-Karin Alm from NanoLund.

Kinga Grenda from Adsorbi and Savannah Zacharias from Glenntex.

Kinga Grenda
Adsorbi

Winner
Savannah Zacharias
Glenntex

The pressure was on

Besides the winners, four other companies competed in the 2023 Innovation Competition finale. With eight minutes each to pitch their innovations in front of the jury and audience, the pressure was on. Here is a glance at their 2D business ideas.



Sustainable graphene lubricants

Jun Zhao from Luleå University of Technology and his team want to make a more sustainable world using graphene lubricants.

– Investing in sustainable lubrication is an important way to reduce friction and wear for addressing carbon dioxide emissions. Our graphene-based nanocomposites and lubricants are environment-friendly, cost-effective and sustainable, says Jun Zhao.

Graphene transistor detecting listeria

André Persson from LayerLogic showed the challenges with recalled and wasted salmon and chicken packages due to listeria. A big problem is that a listeria-test takes days to merely get a result from.

– With our patented graphene-technology we can shorten the time from three days to three minutes, where the customer can test and get results on the production site. Our graphene field effect transistors, as reliable and fast as a PCR-test, is produced with a new easy and cheap graphene transferring method, says André Persson.



2D nanotechnology for concrete

Jan Nordin from Grafoam told us how concrete is made with Portland cement binder, which is a limited and uncertain supply.

– There is a need for new technologies to replace Portland cement. We present a 2D based nanotech package for low CO₂ concrete with improved elasticity and reduced crack propagation. It also has increased strength, superior wear resistance and is frost resistant, says Jan Nordin.

Magnetic fields for orienting graphene

Viney Ghai from Chalmers competed with a new method for orienting graphene in composites using a magnetic field.

– We can unlock the potential of magnetic field-aligned graphene composites, all the way from alignment to application. This allows to truly use graphene's two dimensional properties at the macroscale, says Viney Ghai.

Last year's champions

The 2022 winners of the Innovation Competition, Tenutec and Smena Catalysis, made an appearance on stage and told their story.

Clearly, it had been an eventful year for both start-ups.

– Winning the innovation competition last year made us step out of the lab, says Patrik Björn, CEO of Smena.

Unfortunately, the team discovered that using molybdenum disulfide (MoS₂) for the catalysis was a good process – but not stable enough.

– We tried and failed early. Now we are exploring a different approach with gas sensing instead of catalysis. Here we focus on nitrogen dioxide (NO₂) sensing, for indoor and outdoor air quality assessment, says Patrik Björn.

Josué Mena Gómez from Tenutec, told a back-mirror story that included product sales.

– We used the prize money to develop our business. Branding is important so we built a website, and did a lot of networking, dissemination, utilization, and commercialization. We made our first sales of our sustainable graphene dispersion in Sweden and Ireland and will keep developing the company, says Josué Mena Gómez.



Creating graphene coatings

Graphene coatings are multifunctional and have a huge market potential. In many corridors of Swedish industry, a commercialization could be around the corner. Provexa Technology is one of the companies knocking on the graphene enhanced door.

Provexa Technology has had several graphene projects within SIO Grafen. At this year's Swedish Graphene Forum Christian Werdinius talked about their project focusing on adding graphene to the company's surface coatings in order to increase the electrical conductivity.

This would improve the anti-corrosion properties of the coatings and reduce the risk with electrostatic discharge. Chalmers, Chalmers Industriteknik and RISE have also been involved in the project.

– It is a big step to go from small scale studies in university labs, where ideal solutions are studied, to industrial scales with real coatings containing many additives and processes, says Christian Werdinius.

Early on they got really good results, but they needed to work on the reproducibility. During this time they found that the coatings they did achieve would be very good for EMI and ESD shielding. They therefore changed direction of the project to these applications and also have a new project where they will work on scaling up the process.

– It is important to constantly check and question your results to see where the most efficient and valuable application is, says Christian Werdinius.

Christian Werdinius, Provexa.



Coated facts!

Coatings are everywhere, and can be found on walls, printed circuits, textiles, cars, and much more. By adding graphene to the mix, the purpose is not decorative, but functional and applied to change surface properties – as adhesion, corrosion resistance, wear resistance. The coating can also add a new property, as a magnetic response or anti-bacterial or electrical conductivity, which becomes essential for the product.

Out of 201 projects within SIO Grafen, so far over 80 have been in the “coatings” area of strength. It is without a doubt an area where 2D materials already made an impact and more is coming within the Swedish and European industry. Coatings may be used in various processes: vapor deposition, spraying, chemical and electrochemical techniques, roll-to-roll coating processes and more.

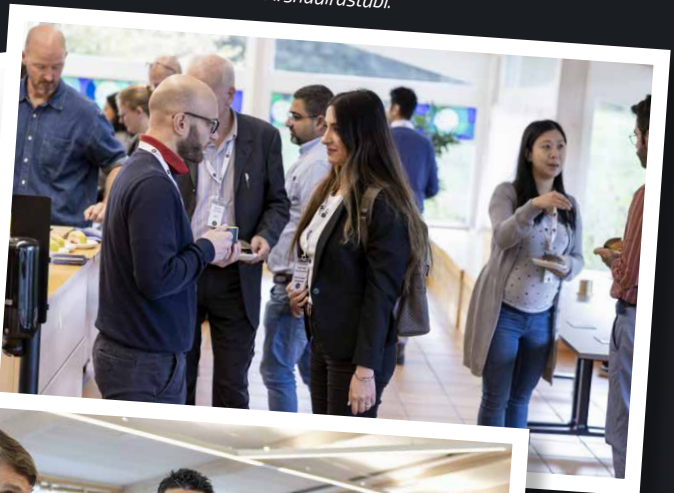
Surface coating with EMI shielding of a protection box for sensitive electronics made by Provexa.



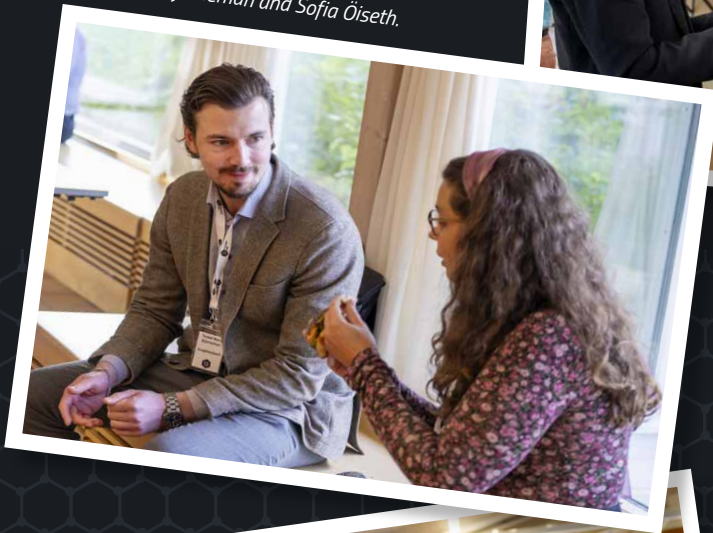
Linda Karlsson, Nazanin Emami and Nikolaus Nestle.



Andrew Marais and Shahrzad Arshadirastabi.



Torkel Nord Björneman and Sofia Öiseth.



Johan Ek Weis,
Samuel Lara-Avila,
Simon He and Lilei Ye.



Fredrik Sahlén and Per Hallander.



Blerina Gjoka and James Randall.

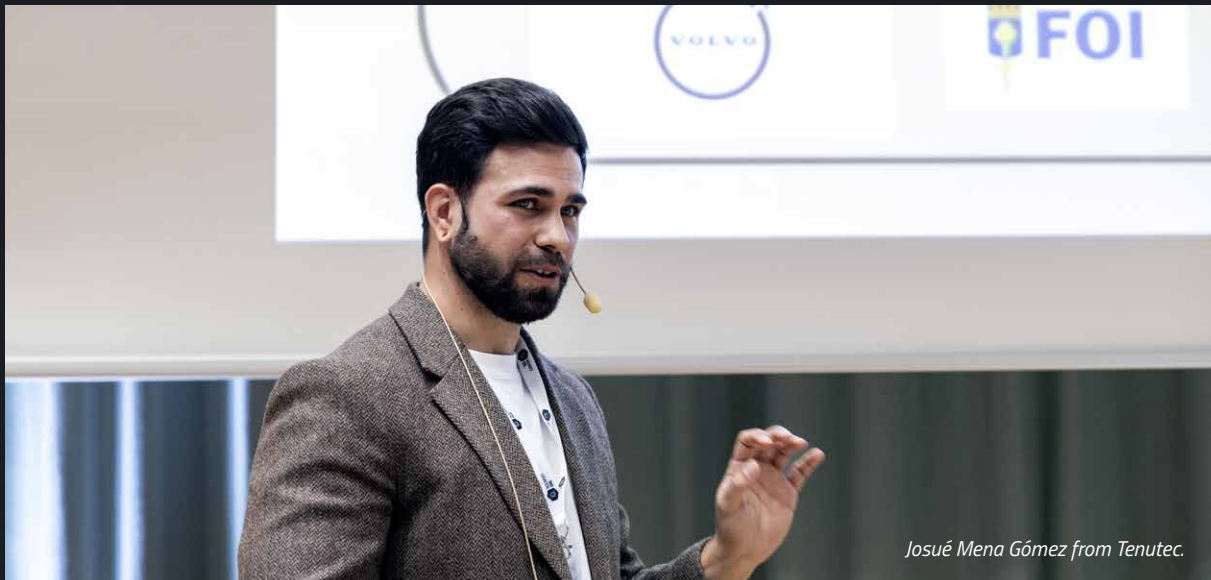


Ulises Méndez Romero, Irina Kravchuk and Erik Khranovskyy.



A growing power of graphene SMEs

Small and medium-sized enterprises, SMEs, are important contributors to job creation and economic development. Also, they have become a growing force in our Swedish graphene network.



Josué Mena Gómez from Tenutec.

SMEs are an important part of the Swedish graphene and 2D material ecosystem. 109 of the 228 organisations participating in SIO Grafen projects have been SMEs (see graphics on page 8).

Some of these also have a focus on 2D materials, such as:

- 2D fab
- Aninkco
- Bright Day Graphene
- Glenntex
- Grafoam
- Grafren
- Granode Materials
- Graphensic
- Graphmatech
- In2Great materials
- SHT Smart High Tech
- Smena
- Tenutec

Two of these interesting companies, SHT Smart High Tech and Tenutec, presented their projects (read about them on page 15) during Swedish Graphene Forum in Lund and several more participated in other projects.

So why are SMEs important? In 2022, there were 3.3 million employees in private companies in Sweden. Of these, 2.1 million were in SMEs, which corresponds to 65 percent. From 1993 to 2019, 82 percent of new jobs were created in companies with fewer than 200 employees. Four out of five new jobs are created by SMEs, according to stats from Svenskt Näringsliv.

– SMEs are at the very core of SIO Grafen. The development of these startups, growing to scaleups and beyond, is essential for our 2DM eco system. It shows the belief that entrepreneurs and investors have in our Swedish deep tech graphene market, and creates job opportunities, says Elisabeth Sagström-Bäck, Programme Director of SIO Grafen.



Testing bulletproof glass.

Graphene in various security applications

Polycarbonate (PC) is used in many security applications, such as bulletproof glass and riot shields, as it is very robust to impacts and transparent. However, it is also prone to scratches and deteriorates with UV light exposure. One solution is using a commercial anti-scratch coating, but these are often more difficult to manufacture.

– We are instead coating the PC with semi-transparent graphene composite. Graphene is transparent in visible light but absorbs UV light and can also reduce the wear. We still need to optimize the graphene coating, but we believe this can have many interesting applications, says Josué Mena Gómez from Tenutec.

FOI and Preventor are also working in the project.



Ulises Méndez Romero from Tenutec.

Graphene-functionalized wood fiber composite

Many new developments are not necessarily focused on increasing the performance of products, but rather on decreasing the environmental impact or reducing the carbon-footprint. Graphene can then be an important part of new concepts by enhancing the properties of other environmentally friendly products that need a performance boost.

– In this project we are investigating if graphene can enhance the thermal conductivity of wood fibers such that they can be used in cooling applications or for EMI shielding. This would significantly reduce the carbon footprint by decreasing the use of metals in existing products, says Ulises Méndez Romero from Tenutec.

Biofiber and RISE are also part of the project.



SHT works on the cooling of data centers.

Chilled data centers

We are using more and more computing power, which leads to an increased need for cooling electronic devices, and even more so for cooling data centers. SHT Smart High-Tech together with Alfa Laval, Barrage Nordx, Bikupa Datacenter 2, Chalmers Industriteknik, Chalmers University of Technology, RISE AB and Submer Technologies are working on solving this by using graphene.

– We are developing a thermal management system based on graphene in a dielectric fluid, which results in a cost efficient, energy saving and environmentally friendly setup, says Emir Bekric from SHT Smart High-Tech.



Graphene can be a part of the 5G-expansion.

Cooling for ICT 5G

Another area where cooling is becoming increasingly important is for ICT 5G wireless radio products. SHT Smart High Tech is investigating if their graphene film or a foam based on carbon fibre and functionalized with graphene can be a part of the solution. Huawei technologies Sweden and KTH are also part of the project and are evaluating the material.

– We have started the tests and are planning more thermal and mechanical characterization in the end of the project. Our films have very high thermal conductivity, but the bonding is also very important to get efficient cooling on a system level, says Dr Murali Murugesan from Smart High-Tech.



Best master thesis award

Joakim Melander from Uppsala University won SIO Grafen's prize for best master thesis for his work at the graphene supplier 2D fab.

For a new and rapidly growing field such as 2D materials, it is important to capture the interest of students on their way into working life. SIO Grafen continues to support industrially linked thesis work on graphene and other 2D materials with up to SEK 40,000.

SIO Grafen also hands out an award for the best master thesis in this field, and the winner 2023 was Joakim Melander from Uppsala University and 2D fab.

The motivation from the jury: "For an impressive thesis work with a nice focus on sustainable and environmentally friendly product development."

– Thank you for this honour, the award and funding of my project with 2D fab. It is extra nice to receive the award here at the Swedish Graphene Forum where I have seen so many different areas where graphene has great potential, said Joakim Melander from the stage.

The worthy winner received the prize of SEK 10,000 and a diploma from SIO Grafen's chairman Fredrik Sahlén.

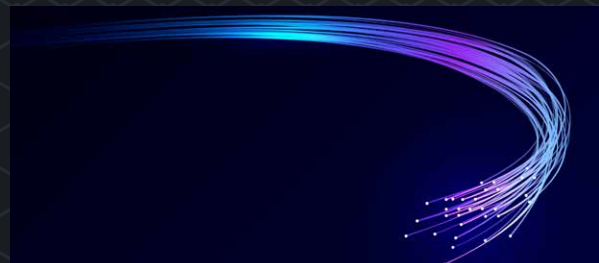


Eco-friendly graphene lubricants

Friction and wear are the main causes of energy loss and mechanical failure, leading to worn-out machineries and significant waste of energy. Now Jun Zhao, who is in a research group in the field of tribology at Luleå University of Technology, together with company partner Sustaina-Lube, are developing eco-friendly high-performance graphene-based lubricants for friction and wear reduction in Swedish machineries.

They use reduced graphene oxide, with no need for filtration and cleaning and no need for additional toxic precursors.

– The work is ongoing, but this graphene nanocomposite shows excellent potential for applications in mechanical industries, says Jun Zhao.



Fiber optics with graphene

RISE, together with two industrial partners, work on coating optical fibres with a nanocomposite of reduced graphene oxide in polymer (polyimide). The project results indicate that the 2D material can provide some improvement to the fibre properties.

– There are some indications that the durability of polyimide coated fibres at elevated temperatures, which was the focus of the project, can be enhanced by this nanocomposite coating. But the increased lifetime can likely be counted in days rather than months at 400 degrees Celsius, says Åsa Claesson, researcher at RISE Fiberlab.

Instead, the nanocomposite coated fibres are perhaps more promising for other project applications. One interesting property is their lower humidity sensitivity compared to other polyimide coated fibres.

Let it snow!

Aircraft de-icing is expensive, time-consuming and an airport bottleneck during cold weather. Could graphene solve this problem? Let's find out.



Mats Bergwall from RISE.

In the project Integraph – Integrated graphene coated glass fibers for multifunctional composites, Grafren from Linköping collaborate with GKN Aerospace from Trollhättan and RISE, Research Institutes of Sweden. Together they will evaluate and demonstrate thermal and electrical properties of multifunctional continuous fibre reinforced composites in aerospace applications.

– We want to manufacture a demonstrator of an aerospace engine part with integrated de-icing functionality and eliminate the need for metallic parts. We are studying the processing, functionality and strength of the graphene treatment from the microscale and up, says project leader Mats Bergwall, researcher from RISE.

Different graphene treatment parameters have been evaluated on the fibre, mainly concerning the strength. When the process parameters were set, the graphene

treatment process were scaled up and laminates were produced to demonstrate functionality and to evaluate material properties.

In these multifunctional panels, de-icing and lightning strike mitigation functionality was tested.

– The de-icing functionality was achievable and selected for continued studies and the demonstrator. Now we study the electrical connections for the active layer in the composite stack and a vast program of mechanical testing is ongoing. The tests will evaluate tensile, compression and interlaminar strengths, says Mats Bergwall.

The next step is to design a de-icing ply and integrate it in one of GKNs products to demonstrate the functionality of de-icing.

Facts: Project partners

Grafren have a patented graphene treatment process for coating of fibres that is investigated for added multifunctionality to structural composites within the project.

RISE collaborates with industry, academia and the public sector to ensure business competitiveness and contribute to a sustainable society.

GKN contributes with their expertise for aeroengine applications and technology need for future sustainable aviation.



Dealing with shared challenges

There are several challenges shared by the whole community working with 2D material innovations. These topics are often too broad or large for individual companies to tackle or even to completely focus on. On the other hand, new insights and results could potentially benefit the entire community. At Swedish Graphene Forum in Lund, seven projects addressing this type of questions were presented. Their common goal is to reduce shared obstacles for improved innovation.

Standardization

Standards are important to create the trust, confidence and reliability for large scale uptake of graphene in a wide range of new products. They are also important to develop better regulation. Åsalie Hartmanis from Chalmers Industriteknik described how their project have contributed to the development of new standards.

– It is important to be involved early in the standardization process and to be a part of the international network, says Åsalie Hartmanis.

Many of the Swedish suppliers of graphene as Bright Day Graphene, Grafren, Graphensic, Graphmatech, and also LayerOne from Norway, are working together with Chalmers Industriteknik, RISE and Swedish Institute for Standards – SIS in the project.

The importance of testbeds

There are many testbeds spread all over Sweden with many different focus areas. These offer the opportunity to evaluate new innovations, including with 2D materials. Many of these also have experience with 2D materials.

– We have made a list where you can see the many opportunities with testbeds in Sweden, which can be found on the SIO Grafen homepage. Take the chance and use these! We have specifically focused on compounding graphene-based fiber composites and on 3D printing in this project, says Ting Yang-Nilsson from RISE.

Linköping university, MEVA Energi, Megger Sweden and Nordic Electronic Partners also participate in the project.

Roll-to-roll graphene coating

Roll-to-roll processing allows many exciting opportunities with graphene coatings. Mid Sweden university are working together with Mondi and UMV to adapt an existing pilot plant into a testbed ready for graphene innovation. They have investigated different types of paper and graphene slurries to optimize the deposition process.

– We can coat 60 centimeters wide paper at speeds up to 300 meters per minute and we have coated several kilometers now. In the final months of the project we will also propose an organization structure for continued use of the testbed in new projects, says Nicklas Blomquist, project manager at Mid Sweden university.

Occupational exposure to graphene

There are health risks associated with manufacturing many materials and products that we use in our daily life. However, this is not a problem as long as it is possible to assess and mitigate the risks. There are generic methods for risk assessment of nanomaterials available, but very little focused on nanomaterials or graphene.

– There are no established occupational exposure limits for nanomaterials. One important aspect of this project is that we can now measure and evaluate how to minimize the exposure to keep the exposure as low as reasonable achievable, says project leader Håkan Tinnerberg from Sahlgrenska university hospital, who is working together with 2D fab, Chalmers, Chalmers Industriteknik and Lunds university in the project.

Life-cycle analysis of graphene products

Life Cycle Assessment (LCA) is increasingly important in most industries. However, there are only very few publications focused on graphene, and data especially from large-scale production is missing. Tomas Rydberg from IVL Swedish Environmental Research Institute, project leader, gave a quick introduction to LCA and explained what they will do in the project, which is still in an early phase.

– We will develop a tool for LCA for graphene products that all organizations will be able to use. We will also collect data and carry out cradle-to-gate analyses for a small, selected set of use cases, says Tomas Rydberg.

The researchers at IVL are collaborating with colleagues at RISE and Chalmers Industriteknik as the main executive partners in the project. Chalmers, EMPA, 2D fab, Aninkco, Bright Day Graphene, Grafren, Graphmatech and Minviro are also participating in the project.



2D Graduate network

It has been identified that there is a need for more networking for young researchers and to connect these to industry and industrial challenges and needs.

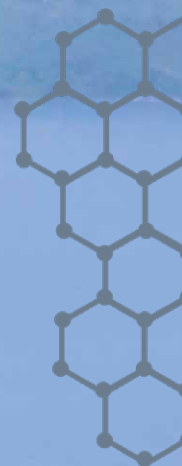
– We therefore started this project to foster collaboration. This can additionally lead to recruitments when the young researchers finish for example their Master's degree or doctoral studies, says Jens Eriksson, project leader from Linköping university.

There are networking activities in the project and also a mobility grant the students can apply for, so they can carry out experiments not possible in their own lab. Linköping university are working together with Chalmers and Luleå university of technology in the project.

Swedish sustainable graphene

Elisabeth Sagström-Bäck, the director of the program office for SIO Grafen, presented an umbrella project called Swedish sustainable graphene, which has helped our graphene community in several ways:

- It allowed participation in Graphene Week where SIO Grafen had a large exhibition booth showcasing 15 demonstrators.
- 16 master thesis students have received funding from the project.
- It has enabled SMEs and the SIO Grafen program office to participate in standardization activities.
- The project enabled RISE to participate in a few international experimental studies for standardization of graphene.
- Perhaps most importantly, the project supported the funding of some of the largest demonstrator projects ever accomplished within SIO Grafen.

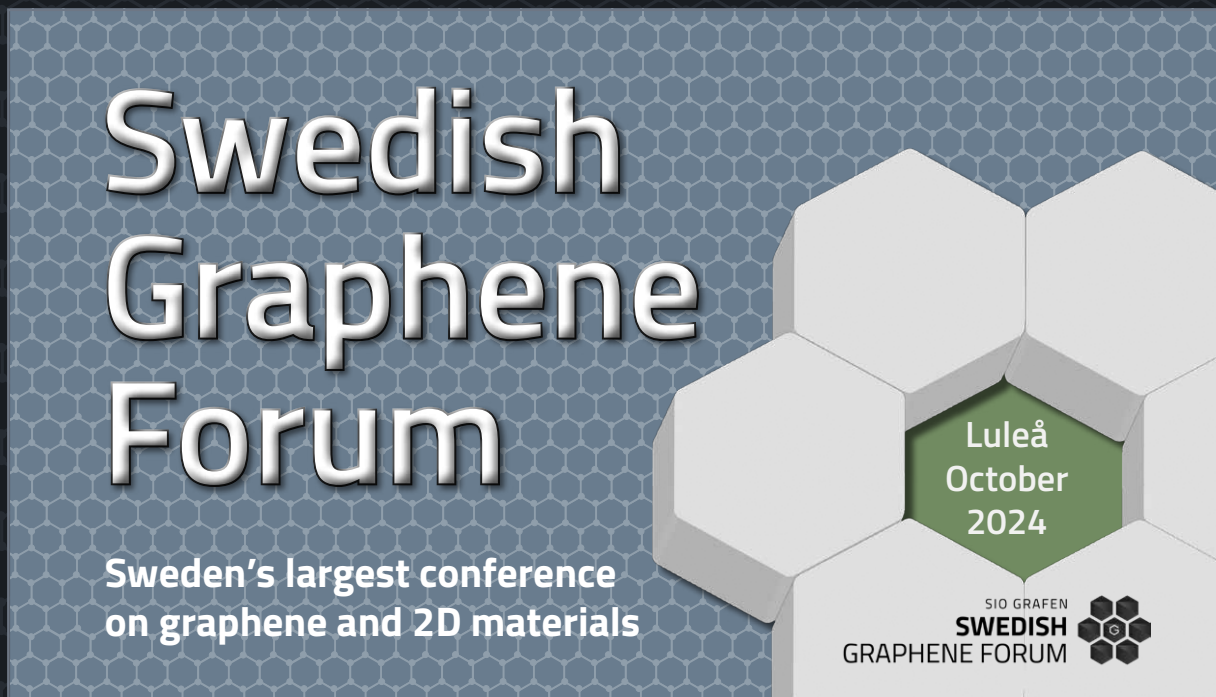


New technology
Ultra-inspirational
Graphene Hallelujah
Brilliant Interesting
Great Welcoming **Necessary**
Inclusive Friendly
Network

How would you describe Swedish Graphene Forum 2023?

We asked the attendees of this year's conference. These are some of their answers.

Source: Answers from SGF Official Survey 2023.



Swedish
Graphene
Forum

Sweden's largest conference
on graphene and 2D materials

Luleå
October
2024

SIO GRAFEN
SWEDISH
GRAPHENE FORUM

The graphic features a blue background with a white hexagonal grid pattern. The text 'Swedish Graphene Forum' is prominently displayed in a large, white, 3D-style font. Below it, the text 'Sweden's largest conference on graphene and 2D materials' is written in a smaller white font. To the right, a cluster of white hexagons forms a larger hexagonal shape, with a central green hexagon containing the text 'Luleå October 2024'. Below this cluster, the logo for 'SIO GRAFEN SWEDISH GRAPHENE FORUM' is shown, consisting of the text and a hexagonal icon with a white 'G' inside.

See you in Luleå 2024!



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