

Swedish Graphene Forum

2024



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Inspired 2D innovation

Swedish Graphene Forum 2024 arrived in Luleå and demonstrated inspired innovation, industry relevance and results beneficial to society. Experienced business leaders mixed with a growing network of young researches and the injection of collaboration was real.

Innovative advanced materials play a crucial part as a Swedish area of strength to ensure continued competitiveness. Here, graphene and other 2D materials bear a key role for a powerful and sustainable future. It is a fact. Join us going forward!



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Deeptech highlights

In this magazine we highlight the yearly progress being made involving graphene and other 2D materials in Sweden. In 2024 the celebratory vibe was prominent in Luleå, we felt the excitement in the northern air.

Since the start of SIO Grafen in 2014 a new industry has developed with 2D materials in Sweden. The strategic innovation program has seen 474 million SEK being invested via 213 projects with 2D materials involving 241 organisations. The progress made has been nothing but astonishing.

The participants at Swedish Graphene Forum in Luleå 9-10th of October saw evidence of that progress on many levels throughout industry and academia. We celebrated the 10th anniversary of SIO Grafen and of the conference itself. In 2024, we also celebrated the 20th birthday of graphene, discovered in 2004 and Nobel prize winning in 2010. The year stands out, and the 2D industry is picking up speed for 2025 and beyond.

A highlight was the involvement of the 2D Graduate Network. The network is a platform for young researchers working with 2D materials from different universities, where they get an opportunity to discuss research, applications, spin-off opportunities and much more. The young network gives industry and research institutes access to employable, talented researchers who are essential for Sweden's success.

Now, let's make the move to a sustainable society possible. The use of advanced materials plays an important role in our country's competitiveness and green transition. SIO Grafen will continue to be an obvious guide through the Swedish 2D industry collectively with you. Which of today's pressing issues will 2D materials be able to solve in the future? Let's meet the challenges together and find out.

SIO Grafen would like to extend a warm thank you to all researchers, companies and students who participated with their research results and innovative solutions in Luleå. The Swedish Graphene Forum 2025 will take place in Västerås – see you there!



Farid Akhtar, HIPOR Materials.

The future of concrete

In December 2024, four graphene reinforced concrete barriers were placed at Skolhusallén in Sundsvall. With enhanced frost-resistance and greater durability, it is a key step for new and sustainable concrete road infrastructure.

A new graphene-based additive is being evaluated for the concrete industry. It has the potential to strengthen the concrete and make it frost-resistant with significantly lower addition of Portland cement.

– Frost-resistance is a big problem in the concrete industry, and here we use graphene to reduce crack formation. It increases strength and toughness at the same time. We believe we can reduce the use of Portland cement (with >80 percent) which makes this very sustainable, says Professor Farid Akhtar from Luleå University of Technology and HIPOR Materials.

The demonstrator project is verifying previous lab results in full-scale field studies. In May 2024 they made six tonnes of concrete at field trials in Rättvik. Now they test the freeze-resistance, wear and strength in Sundsvall – in centre rails reinforced with graphene. The barriers are on display for evaluation together with concrete railings made of reference materials.

– When we add very little graphene inside cement we see a strong effect. Concrete producers are very excited when we approach them, they want new, more sustainable products and are ready to adapt, says Farid Akhtar.

Facts!

The project does pilot scale testing of 2D additives in concrete. Project partners are Grafoam, 2D fab, Swerock, Gunnar prefab, HIPOR materials, SIC and RISE.



Graphene reinforced concrete barriers in Sundsvall.



The pilot line in production.



Sofia Öiset, Chalmers Industriteknik.

Industrial scale coatings

A challenge with the current enhanced electrification of society is to shield delicate components from electromagnetic interference. Proveda Surface Technology is working together with Chalmers, RISE, Layer One and Chalmers Industriteknik to alleviate these problems by developing graphene containing protective coatings.

– We have already had multiple successful projects within SIO Grafen. The focus of this project is on scaling up the technology to real industrial applications. We are right now building a pilot plant at Proveda that will be able to supply the technology to real products, says Sofia Öiset from Chalmers Industriteknik.



Essential tool is being created.

LCA prototype

The interest and need to make lifecycle assessments continues to grow. A large consortium (IVL, RISE, Chalmers Industriteknik, Chalmers, Empa, 2D fab, Aninkco, Bright Day Graphene, Grafren, Graphmatech and Minviro) have created a tool to facilitate the work on LCAs.

– We wanted to make a tool that is easy to use for everyone. It is therefore based on Excel and is accessible to all. It serves as a stepping stone into the world of lifecycle assessments, says the project leader Tomas Rydberg from IVL.

An important part of the project was to create a database with all the relevant information. It is now possible to compare the footprint of a product with graphene with a conventional product for example.



Papiya Bhowmik, Linnaeus University.

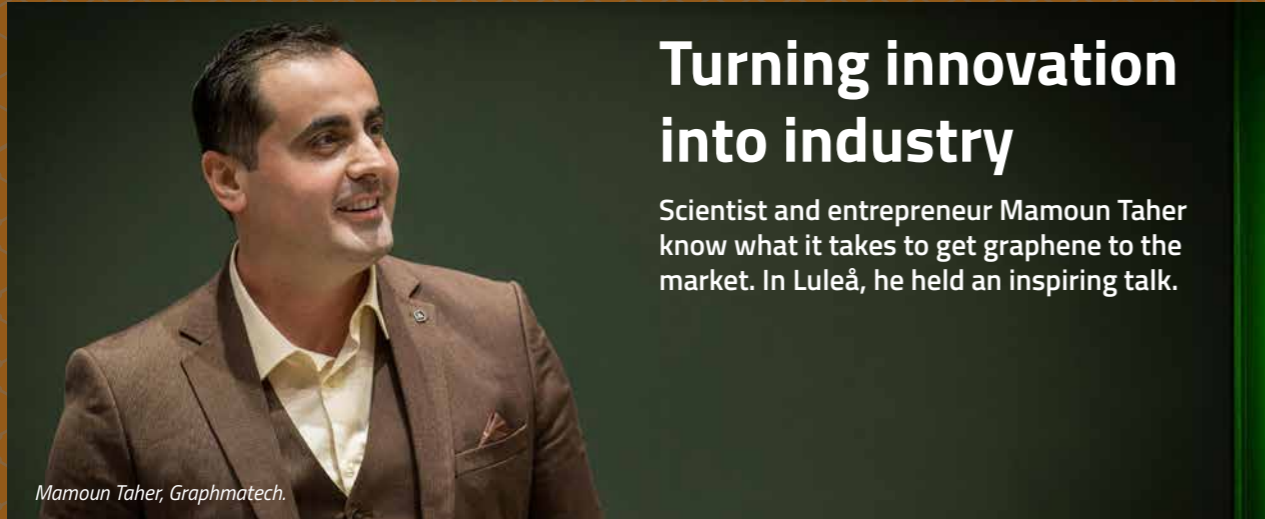
Bioadhesive for particleboards

Particleboard panels are widely used in furniture. The drawback is that they emit toxic chemicals (formaldehyde) from the adhesive during production. IKEA, Avantium, Bright Day Graphene and Linnaeus University are working together to develop a biobased adhesive.

– Graphene-reinforced adhesives show enhanced bonding characteristics due to their high surface energy and compatibility with lignocellulosic surfaces. Additionally, the graphene enhances thermal conductivity, thereby may reduce the curing temperature of the adhesive, says Papiya Bhowmik from the Linnaeus University.

They showed a significant effect of graphene in the performance of adhesives in wood lap joints and will continue validation in the particleboard panels at the IKEA facility. Applying graphene-based adhesives on 3-layer particleboards was also considered to overcome the production challenges and justify the high cost of graphene.





Mamoun Taher, Graphmatech.

Turning innovation into industry

Scientist and entrepreneur Mamoun Taher know what it takes to get graphene to the market. In Luleå, he held an inspiring talk.

Graphmatech is a spin-off from Uppsala university, founded in 2017 by Mamoun Taher. Headquarters are in Uppsala, with one subsidiary in Abu Dhabi. Investors in the company are ABB, InnoEnergy, Molindo Energy, Almi Green and Walerud Ventures.

– There are and have been many very interesting projects within SIO Grafen. All of these have had an industrial mindset. However, it's not easy to go all the way from an idea to make a profit, says Mamoun Taher.

The Graphmatech technology platform covers different verticals of industrial applications, such as energy, metals and mining, industrial packaging, automotive and defense and 3D printing. The multifunctionality of the material is a key factor.

Graphene-based ideas can be transformed into a diverse range of products, making innovation and product development relatively straightforward. The key lies in identifying a specific challenge that your innovation addresses, then scaling that product into an industrial-level business.

However, establishing a successful business around graphene innovation requires more than just technological expertise. It necessitates developing a robust supply chain, building manufacturing capabilities, securing investments, and assembling a capable team to effectively execute the industrialization process, as noted by Mamoun Taher.

Graphmatech are successfully navigating the industrialization landscape with its graphene enhancing technology. Both in polymers, with graphene added either by mixing or coating, and in metals where they add graphene properties by coating.



Kinga Grenda, Adsorbi.

Competition winners are evolving

Adsorbi and Glenntex won last year's SIO Grafen Innovation Competition and shared 600,000 kronor. They look back on eventful years.

The two startup-companies, both with roots from Chalmers in Gothenburg, have had good use of the experience of going through – and winning – last year's competition.

Glenntex uses graphene to simplify and improve sustainable plastic recycling.

– Winning the competition really helped us a lot. We used the money to meet challenges and develop the company and are very hopeful of the future. We hired people, me included, in 2024 to keep on growing, says Anders Sonesson, CEO at Glenntex.

Adsorbi has developed a wood-based adsorbent material to capture pollutants

– Using graphene as an additive enables high performance and more specific capture of gaseous pollutants. Next step is to identify specific market segments within air filtration with need for high performing and sustainable adsorbents with graphene, says Kinga Grenda, CTO at Adsorbi.



Graphene in disguise

A graphene based military camouflage net that is lighter, stronger, with increased performance and more environmentally friendly, is being made in Sweden.

There are many advantages of graphene in textiles for defence applications. Graphene has an extreme electrical conductivity and at the same time helps to reduce weight.

– With the use of graphene, the camouflage gets 20 percent lighter. If you tell that to a soldier, it is a big thing. Soldiers love things that are light, says project leader Johan Jersblad from Saab Barracuda.

Saab's business unit Barracuda in Gamleby is one of the world's largest manufacturers of military camouflage. The war in Ukraine and Sweden's entry into NATO obviously play a role in a growing demand, and electrically conductive textiles are an important material in several defence products.

Since graphene is electrically conductive, it protects against radar detection, and it also has the potential to increase protection in the thermal range.

But above all, it is lighter and stronger than the electrically conductive chemicals traditionally used for radar protection.

– Reduced weight makes the material easier to use and transport, and with less combustible material, less flame retardant is needed which make this camouflage more environmentally friendly, says Johan Jersblad.

The textile fibres are coated with graphene using Linköping company Grafren's unique coating technology. Graphene is integrated into the fabric, making the whole fabric electrically conductive. The companies have been working together in SIO Grafen projects for many years.

The goal is to deliver a graphene based camouflage net that is lighter, stronger, more environmentally friendly, user friendly and with increased performance.

Facts!

The project "Graphene camouflage with advanced weight and functional properties" involves project partners Saab Barracuda, Grafren and Engtex.



Johan Jersblad, Saab Barracuda.



Young researchers making progress

The 2D Graduate Network is an important part of the Swedish 2D material ecosystem. In Luleå, young researchers won awards and collaborated to improve career paths.

When young researchers join forces with key actors from the industry, exciting things happen. In Luleå discussions ran high during days of sharing knowledge, contacts and possibilities.

For students, the network is both useful for finding new collaborations during ongoing studies and for finding a job after graduation.

– Since we can use 2D materials for a wide variety of applications, this research has the potential to unite people from different research fields in a unique way. We get inspired by each other, says PhD student Johanna Huhtasaari from Chalmers.

Increase the links

For companies and institutes, it is a possibility to associate with future employees in this growing deeptech area. Vinnova finance the network through the strategic innovation programme SIO Grafen.

– We see a need to increase the links between young researchers at different universities and between researchers and industry. It is important that PhD students and other students have a strong presence and a natural place in the Swedish 2D material ecosystem, says Elisabeth Sagström-Bäck, Programme Director of SIO Grafen.

The group met at Swedish Graphene Forum where Joyal Jain Palakulam, Johanna Huhtasaari, Naveen Shetty, Matheus Mendes and Viney Ghai held talks during the new talent parade. After the conference they and the rest of the network gathered for a lunch-to-lunch workshop.

Energetic and hard-working

Running 2D Graduate Network are experienced researchers and professors Samuel Lara-Avila from Chalmers, Nazanin Emami from Luleå University of Technology and Jens Eriksson from Linköping University.

What is the key to the continued growth of this important group?

– People are the most important ingredient! Fortunately, the members here are a bunch of energetic, smart, hard-working and ambitious young people who make the network thrive, says Samuel Lara-Avila.



Samuel Lara-Avila.



Joyal Jain Palakulam



Matheus Mendes.



Viney Ghai.



Johanna Huhtasaari.

Scan the QR!

SIO Grafen's 2D Graduate Network allows young scientists working actively in any area of 2D materials to quickly establish and keep contact with peers having similar or complementary interests. The network is also an avenue to connect with Swedish industry and organizes recurring seminars, meetings, and an annual workshop.

Are you a Masters, PhD or Postdoc actively working on graphene or other 2D materials? Are you interested in establishing your own network in the field? Join us via the QR.



Fanny Sandblad won the Master Thesis Award.



Naveen Shetty won the Best Poster Award.

Two winners!

Fanny Sandblad won the SIO Grafen Best Master Thesis Award of 10 000 kronor, a diploma and well-deserved honour, for her work at Graphmatech and Uppsala University.

Jury motivation: Solid work with a consistent scientific approach supported by relevant references. Well written, well presented and high industrial relevance.

Naveen Shetty et al. from Chalmers won Best Poster Award for poster "Ultralow 1/f noise in epigraphene devices".

Jury motivation: For a scientific clear message, a good visual presentation and one step ahead to the application.



Jonas Löfvendahl welcomed the participants.



Danilo Carastan and Matheus Mendes.



Margareta Groth from Luleå university of technology.



Patrik Bjöörn and Jon Wingborg.



Fredrik Sahlén's celebration speech.



Fredrik Sahlén, Nazanin Emami and Elisabeth Sagström-Bäck.



Anne Farbröt from Sahlgrenska.



Per Hallander from Saab.



Patrik Johansson from Chalmers and Graphene Flagship.



Lilei Ye from Chalmers Industriteknik.



Johan Liu from Smart High-Tech.



Top production speed with new adhesives

Bio-based adhesives with graphene improves productivity, properties and sustainability in wood-based products.

– It is substantial improvements, says Britta Andres from Swedish graphene manufacturer 2D fab.

The idea to enhance bio-based adhesives with graphene for sustainable wood-based products is a successful SIO Grafen project involving 2D fab, BIM Kemi, DS Smith, Ikea, SCA, Swedish University of Agricultural Sciences and Tetra Pak. They approached the challenge via three products.

Wood panels

45 million m³ wood panels, that uses 3 million tons adhesives, is produced in EU annually. A problem in production is the use of formaldehyde, which is harmful, non-renewable and makes recycling problematic.

– This is a huge market! We can solve the problem with formaldehyde by making biobased adhesives with graphene. In lab tests and pilot-scale tests we see a very good processability that reduces the press time. We got indications that this can increase production speed with 25 percent, says Britta Andres.

Corrugated board

The problem with corrugated board is limited productivity due to slow drying. With graphene as a glue bonding enhancer, it both increases productivity and reduces energy consumption.

– Our graphene suspension produced by 2D fab can very much improve this. With less than 0,1 percent graphene it clearly improves drying and bonding of glue, and we see an increase in production speed with 25 percent. The cardboard is on the market, says Britta Andres.



Britta Andres, 2D fab.

Paper straws

With paper straws, the problem is insufficient wet adhesion. The solution is graphene, and the goal is to increase productivity and reduce energy consumption.

– When we use graphene as glue bonding enhancer it improves wet adhesion and we see an improved drying process. The drying goes 40-60 percent faster, says Britta Andres.

Graphene coated natural fiber for marine applications

Natural fibers have been used increasingly the last few decades as they allow weight savings and a lower CO₂ footprint. They are however sensitive to water and moisture, which limits the use cases. Linköping University, Grafren, IMA, RISE, Trifilon and X Shore are collaborating to use graphene in order to protect the fibers from environmental effects.

– This has the potential to impact a wide array of applications and agenda 2030 targets. We have focused on the marine industry in this project with interesting results and hope to continue in a follow-up project, says Mohamed Loukil from Linköping University.

After Swedish Graphene Forum, the consortium got a new SIO Grafen project approved. Now they will make a demonstrator, a hull of a boat on a small scale. The exciting project will continue until June 2026.



Mohamed Loukil, Linköping university.



Arne Quellmalz, In2great Materials.

A transferring triumph

Transferring 2D materials from the growth substrate to the final product is a key moment. Now, there is a way fully compatible with the ecosystem of the semiconductor industry.

There is a large potential for graphene and other 2D materials in future semiconductor technology. The 2D materials can either enhance conventional CMOS technology or replace it in other applications.

Patented method

There are many people working on different aspects of this globally as there are several challenges. In2great Materials are focusing on the challenge of transferring the 2D materials from the growth substrate to the final product.

– Researchers have invented many manual methods that works for them, but that are not scalable or suitable for industry. We use established semiconductor equipment and materials in a large area and high-volume process. Our patented method is thereby fully compatible with the ecosystem of the semiconductor industry, says Arne Quellmalz from In2great Materials.

Various 2D materials

Many transfer methods have issues with degradation of the material from contamination, doping, wrinkles, strain or with adhesion to the substrate.

– Our method is very clean. It is suitable for various 2D materials and growth substrates. The requirements on the material and surface properties of the target substrate are rather relaxed, and adhesion is not a problem, explains Arne Quellmalz.

Important steps

In2great Materials have collaborated with AMO and KTH in this project and have taken important steps towards the application of 2D materials in functional components, opto-electronics and logic circuits.

– Our products provide a readily deployable solution for a major manufacturing problem of 2D material devices, Arne Quellmalz concludes.

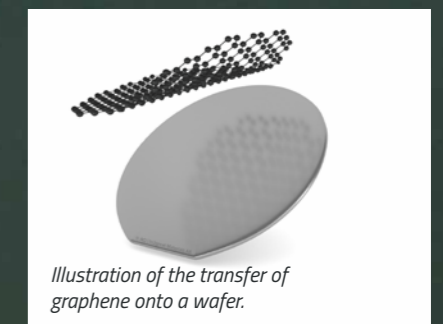


Illustration of the transfer of graphene onto a wafer.





Get in touch with SIO Grafen!

SIO Grafen, with Chalmers Industriteknik as host organisation, always work actively to find solutions that fits different organisation's 2D challenge. Please contact us – together we will keep building the Swedish 2D industry.

Email info@siografen.se or scan the QR.



A decade of progress

It was a birthday to remember when SIO Grafen celebrated its 10-year anniversary as a Strategic Innovation Programme.

SIO Grafen have been around for 10 years and look straight ahead towards a bright future for innovative advanced materials in Sweden. In Luleå, it was time to celebrate a decade of progress as SIO Grafen turned 10.

– We celebrated the anniversary with cake and a very nice dinner in the evening. Many well-executed and interesting demonstrator projects were presented during the conference. The wide range of applications for 2D materials was clearly shown. There were inspiring visits to Luleå university of technology, Swerim and Talga. A very well organised conference where I would like to send a warm thank you to the local host Luleå university of technology and to SIO Grafen's programme office, said Fredrik Sahlén, Senior Principal Scientist at ABB and chairman of the SIO Grafen board.

At the same time Swedish Graphene Forum celebrated 10 years as a conference. Nazanin Emami, Professor in Machine elements and vice chairman of the SIO Grafen board, was pleased with the arrangement.

– The development of graphene and other 2D materials is moving forward rapidly. Luleå university of technology has been an active partner in SIO Grafen since the beginning, and it was fitting that we hosted this anniversary and Swedish Graphene Forum, she said and concluded:

– During the last 10 years more than 200 projects have been financed through SIO Grafen and this year we listened to some of these highly successful projects.



Fascinating research

During Swedish Graphene Forum the participants got exciting insights in local research and development at Luleå university of technology and companies Swerim and Talga.

SIO Grafen sends out a big thank you to Nazanin Emami for her efforts to make Swedish Graphene Forum a success. The professor, who has worked with graphene for 14 years, gathered a devoted crew of PhD students and postdocs who arranged appreciated study visits at departments of Energy engineering, Materials engineering, Bionano composites and Machine elements. They showed fantastic research and lab activities going on in Luleå, and the university was a perfect host of Sweden's largest annual graphene conference.

Circular industry

Last thing on the agenda was two excellent study visits at companies Swerim and Talga. Swerim conducts industry-oriented research and development on metals and their

path from raw material to finished product. They want to strengthen the competitiveness of industry through increased product quality, higher resource efficiency and more sustainable manufacturing processes. Swerim's vision is a fossil-free and circular industry.

Battery materials

Talga is a leader in the development of sustainable battery materials. Via innovative technology, Talga offers a secure supply of products critical to the green transition. Battery materials under development include an advanced silicon anode product, recycled graphite anode material and conductive additives for cathodes. At the study visit on-site in Luleå the participants got an interesting look into the procedure.





Tobias Storsjö, Sahlgrenska.

Graphene powder.

Occupational exposure and toxicology

The probably most engaging presentation of the forum was given by Tobias Storsjö from Sahlgrenska about occupational exposure and toxicology of graphene.

As we all know there are many forms of graphene-related 2D materials, such as different sizes, oxygen levels, etcetera. Unfortunately, this leads to that although there are many toxicological studies, it is difficult to draw many conclusions.

– Oxygenated forms are generally more toxic than pure graphene, whereas the inflammatory response depends on the lateral size. However, there are very few toxicological studies that really reflect real-life exposure, says Tobias Storsjö.

Storsjö and his colleagues have measured the occupational

exposure to graphene at multiple organisations the last few years. They use several identification techniques and quantification methods, which have allowed the organisations to identify which process steps leads to the highest exposure.

– They can then reduce any potential risks by focusing on the more hazardous steps. Now, the most important thing for the future is more collaboration and more measurements in manufacturing facilities. Please reach out to us if you are working with graphene and want to understand your potential exposure, says Tobias Storsjö.



Johan Ek Weis, SIO Grafen.

Support the ecosystem

A strategic SIO Grafen project has made an impact on students, standardisation and more.

SIO Grafen is aiming to reduce barriers for taking 2D materials from the lab to societal benefit. One project has supported the ecosystem this year by:

Funding six Master theses. These have been about laser-induced graphene, graphene oxide to influence friction, graphene in polymer masterbatches and in concrete, recyclability of packaging and about graphene toxicity.

An Innovation competition which you can read more about on page 6.

Facilitating work on standardisation allowing SMEs to influence ISO standards.

– These are important efforts that increase the competence and entrepreneurship focused on graphene in Sweden. It's also crucial that Swedish interests are considered when new standards are developed, which this project enables, says Johan Ek Weis from the SIO Grafen programme office.



Hydropower in 2D mode

Newly developed self-lubricating polymer composites bearings with graphene can be a game-changer for hydropower turbines. The goal is to provide the industry with a sustainable solution that can improve both production and turbine lifetime.

Bearing surfaces in hydropower turbines are in motion and contact with counter surfaces, under demanding conditions. This tribological contact result in friction and wear.

– High friction and low wear resistance affect the service-life of the component significantly. Also, wear particles from polymeric bearings containing PFAS chemicals released into rivers and nature, says professor Nazanin Emami.

Project partners Luleå university of technology, Vattenfall, Fortum, Skellefteå Kraft, Statkraft, Sustainalube, and Trelleborg are working on 2D based multiscale polymer composites with improved tribological performances as tribo-material in hydropower turbines.

– This technology aims to solve issues with short lifespan and to reduce or eliminate harmful PFAS chemicals in today's polymer bearings used in turbines, which decreases maintenance needs and improves energy efficiency, says Nazanin Emami.

Graphene derivatives and surface functionlaised graphene derivatives have the potential to be used as solid lubricant in thermoplastic polymer composites. Results show a reduction in wear rate and friction significantly.

– We see data were polymer materials show wonderful improvements, very stable. If we can almost double the life expectancy of bearings it is fantastic news for the energy industry, says Nazanin Emami and continues:

– This project is Vinnova funded through SIO Grafen and we are very happy to be elected in the IVA-100 Research to Business list in 2024 which is a testimony to the commercialisation capacity of this project.

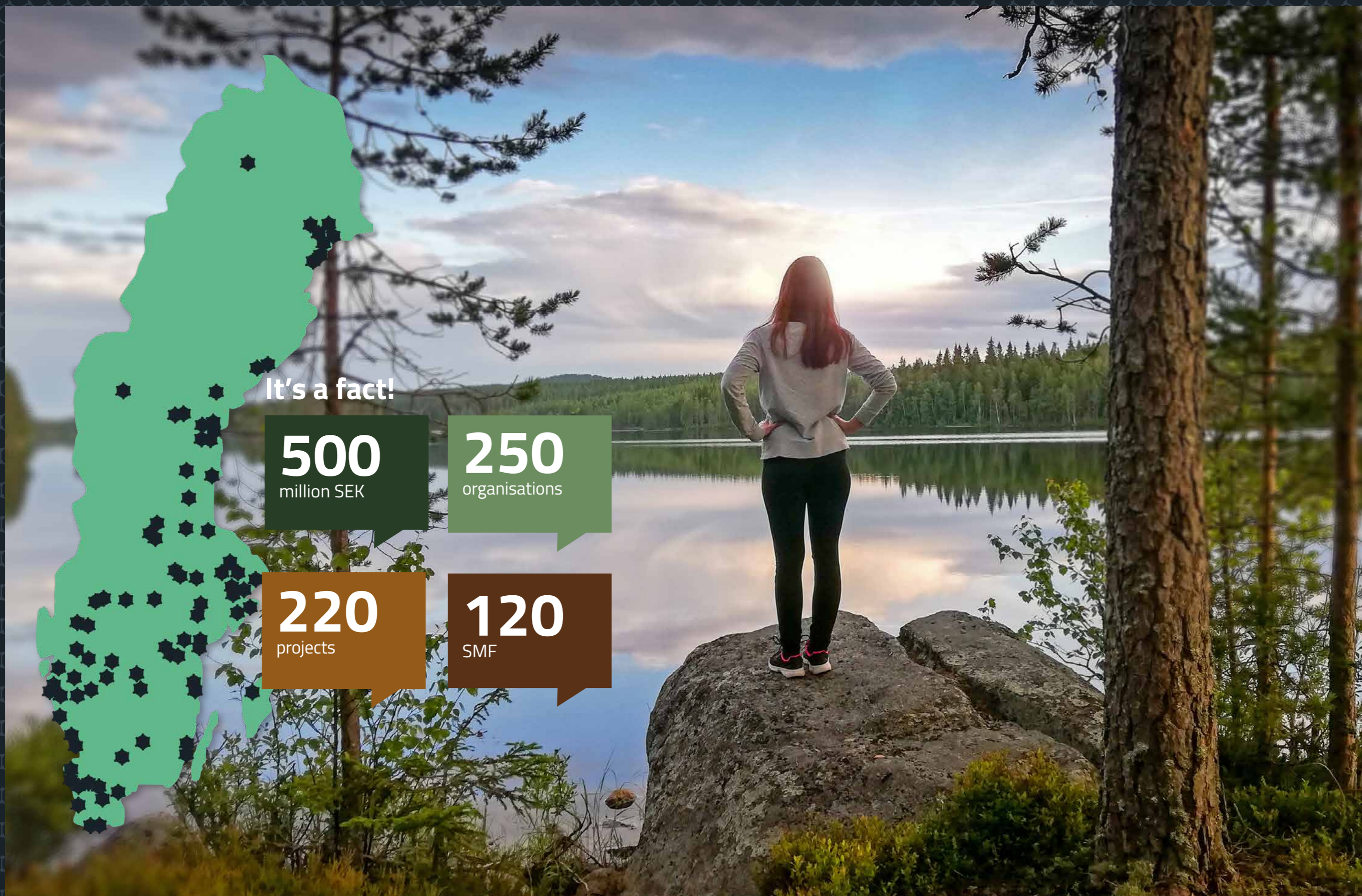


Prototype of full-scale bearings.



Nazanin Emami, Luleå university of technology.





It's a fact!

500
million SEK

250
organisations

220
projects

120
SMF

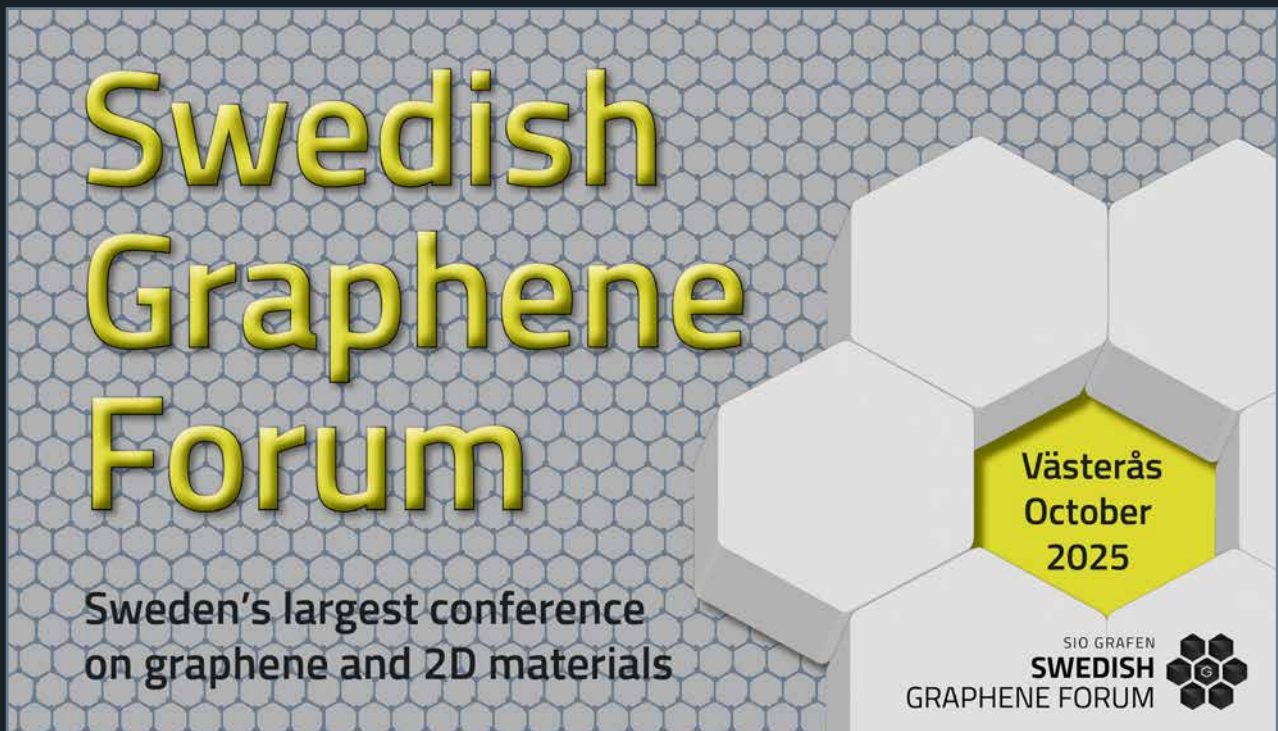


Innovative
Fruitful Knowledge-expanding
Friendly Well-organized
Networking Fun Inspiring
Excellent Collaboration
Useful Graphene is future

How would you describe Swedish Graphene Forum 2024?

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

Source: Answers from SGF Official Survey 2024.



See you in Västerås 2025!

