Swedish Graphene Forum

2021

Improved camouflage Page 16

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Heading for the future

Swedish Graphene Forum 2021 was a great success, an all-time high with more than 160 attendants where over 28 presentations were held at great pace.

- We are pleased to be able to accelerate Swedish graphene development with important projects. Graphene is a new and sustainable material that requires important efforts to reach out to Swedish industry. Swedish Graphene Forum showed everyone that we are on the right path, says Elisabeth Sagström-Bäck, Programme Director at SIO Grafen.

This magazine shows the range of the graphene industry and the power of the growing Swedish graphene community. Enjoy!









Do you have questions? Contact: info@siografen.se

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Swedish Graphene Forum volume 2021 Produced by SIO Grafen in December 2021 Words by Eleonor Hendar and Jonas Löfvendahl Design by Astrid Hedenström Images by Astrid Hedenström and Jonas Löfvendahl/Shutterstock/Unsplash

It is just the beginning

Batteries, sports equipment, resource-efficient rubber and camouflage applications. This year's Swedish Graphene Forum offered so many interesting research results that we decided to dedicate a magazine to it.

In many ways, Swedish Graphene Forum is SIO Grafen's most important event. It is where actors, researchers, members, students, and founders come together and really get to see what can be accomplished with one of the most complex and versatile materials known to humankind. It is a platform where newfound knowledge and challenges are shared. Where project results enable future innovations to grow.

Swedish Graphene Forum 2021 was arranged digitally, a decision we wouldn't have made under ordinary circumstances, but one that made it possible for more participants than ever to join. Together we reached an all-time high of over 160 attendants. During 28 presentations held at great pace we got to see the exciting future of graphene – thank you all!

The day also entailed interesting discussions, great engagement in the chat, many new perspectives on graphene and a clear desire for enhanced collaboration towards commercialisation. Now, we at SIO Grafen have an important role in challenging our network with the needs of our project participants.

Although the pandemic has changed much about the world, our primary focus remains on how graphene can contribute to some of the challenges that we currently face. Graphene is a potential problem-solver across a great deal of industries and applications when used the right way, and can play a decisive role towards a sustainable future.

This magazine is filled with complicated issues and highly skilled people who dedicate their working hours addressing complex challenges in a very stubborn and passionate way. It is a glimpse of what was presented at Swedish Graphene Forum 2021, and of what we will be hearing about Swedish graphene in the future. We are quite convinced it is just the beginning.

Stay curious,

Programme Office SIO Grafen





"We aim to take graphene to the next level through collaboration and innovation."



Different types of projects

Depending on how mature a graphene idea is, SIO Grafen offers different types of project forms. They all have in common that the projects are carried out in collaboration and that at least one Swedish company is part of the project group. Our project forms:

Feasibility study

Shorter project testing an innovative idea to use graphene or other 2D materials to solve an industrially relevant issue. When the project is complete, you know if the idea has the technical and market potential to move forward.

Innovation project

Project of a maximum of 3 years that further develop a solution with graphene or other 2D materials, for further steps towards industrial use. When the project is finalised, you see the functionality and industrial potential of the concept, have a clear plan for how the results can be used industrially and know if you need new parties for a complete value chain.

Preparation project

Shorter project for graphene concepts with verified function and industrial potential, but with needs to further develop the idea or value chain to be able to apply for a demonstrator project.

Demonstrator project

Project of a maximum of 3 years that verify that the graphene concept works in a relevant environment. After the project, you have a physical demonstrator, you know how the result can be used industrially and the complete value chain is in place.



Roland Kádár, Chalmers

High performance and scalable tailored graphene – polyolefin nanocomposites

In this project, Borealis AB, Chalmers and Hot Disk AB investigated a novel type of hierarchical graphene filler in polymers using scalable melt mixing procedures. The goal: To develop a novel class of high-performance graphene - polyolefin nanocomposites.

– The hierarchy of the fillers includes the primary particles, reduced graphene oxide consisting of 3-5 monolayers and a 3-dimensional aggregate thereof. While overall the filler dimensions exceed nanoscale, the properties imparted by the fillers to the polymers is the result features at nanoscale level, project leader Roland Kádár, Chalmers, explains. The incorporation of the filler in polyolefins results in high performance electrical and thermal properties. For example, the electrical percolation threshold obtained in polypropylene is the lowest recorded in the scientific literature to date for similar preparation methods.

 The key benefit is in terms of scalability, in that the powder is mixed directly with the polymer using melt mixing without any complex preparation steps.

Guan Gong, RISE

Graphene modified composites for long-term high-temperature applications stage 2

RISE SICOMP, GKN Aerospace, Nexam Chemical and Woxna Graphite wanted to use graphene in composites at high temperature in an aerobic environment.

– The background was an increased use of lightweight and advanced composites in aviation from environmental point of view. And an increased use of functional inclusions, e.g. graphene, in aircraft from a technological and market point of view. Plus, a specific use of graphene for long-term high-temperature applications in aerospace, says Guan Gong. The demand from aerospace and aeronautics for polymeric composites used in long-term high temperature applications, e.g., warm parts in aircraft engine initiated this specific project.

– Graphene has shown clearly positive effect on improving the resistance of high-temperature resin based CFRP (Carbon-fiber-reinforced polymers) to thermal oxidation at high temperature of 320°C in aerobic environment, by protecting composite surface and/or by being dispersed in the resin matrix, says Guan Gong.

Chao Xia, Applied Nano Surfaces Functionalized graphene as structural fortifier for polymers and coatings

In this project, Applied Nano Surfaces, Chalmers and SHT Smart High Tech teamed up to tackle the corrosion problem in heat exchange plates used in sea water.

 Corrosion is not environmentally friendly and equals high cost, which is an issue we wanted to address, says project leader Chao Xia from Applied Nano Surfaces.

Their solution was to functionalise graphene and build cross-linking between graphene and the epoxy binder to reinforce the anti-corrosion property of the waterborne coating.

 We have successfully functionalised graphene, in both small and large scale. The formulation looks very good. He explains that reaching a high degree of functionalised graphene is all about balance.

 You can't get everything perfect at the same time. You must tailor the functionalization degree to achieve the properties you're looking for.

In terms of reproducibility, the project group still experience differences from batch-to-batch.

But if the functionalisation is crafted in relation to the graphene, we can still achieve good corrosion protection results.

"You can't get everything perfect at the same time."

Innovation projects

Romain Bordes, Chalmers Graphene in loudspeaker membranes

In this project Chalmers, Chalmers Industriteknik, Transient Design and Marten wanted to enhance the membranes of speakers with graphene. – For the high-end market, membranes are often made of ceramics or diamond with high stiffness, low deformability and low distortion over an extended frequency range. That's the competition, says Romain Bordes.

Membranes for smaller products (headphones) with graphene have been done, and also products with high performing cellulose. The project now look into that direction and seek to integrate graphene oxide in membranes of larger sizes.

The aim was to move from coating to selfstanding diaphragm. A complex process in the relation of drying and the high TRL needed for testing – size, weight, shape. And understanding the challenges of working with colloids of different dimensions. – We are on our way to have materials being integrated in drivers, so that we can test it, says Romain Bordes.

Murali Murugesan, SHT

Graphene-enhanced prefabricated cement wall with insulation function

Controlling the level of noise is a key responsibility in the construction industry but using modern materials this is not always an easy equation. In this project, SHT Smart High-Tech, Svenska Cement and Chalmers have been addressing sound problems caused in cement and concrete buildings.

 We want to improve many important issues, but the composition of cement is very complex, says project leader Dr Murali Murugesan, SHT Smart High-Tech.

The project scope was to use a graphenebased foam as an insulation material in Svenska Cements pre-cast walls and to study the sound isolation and mechanical properties without compromising temperature related stability. By engineering the internal structure of conventional cement using an interconnected network based on graphene, it is possible to enhance noise absorption as well as other important properties.

The partners have successfully produced a graphene foam and graphene foam enhanced cement composite, including completing characterization of the materials. So far, graphene foam enhanced cement looks promising as a sound absorbing material.

"The composition of cement is very complex."

Sri Iyer, Senseair

CVD graphene-based IR detectors

The goal was to design and fabricate 2-10 µm IR-detectors using CVD graphene with coupled metal antenna elements for automotive applications. A consortium of SenseAir, Halmstad University, MST at KTH and RISE gave it a go in a continued project.

– We made a lot of studies. This project was very much about to understand things on the process side, and we learned a lot. Here we use graphene as a carrier transport medium. The graphene is good as a transfer layer, now we need more measurements and tests. They demonstrated IR absorption in the metal antenna/graphene hybrid devices which is in good agreement with theoretic modelling. They also saw high coverage of graphene on the substrates in 4 wafer scale after graphene wet transferring process, which is confirmed by Raman spectra before and after the graphene transferring process.

 Also, good Ohmic behaviour was revealed by I-V characteristic after graphene transferring on the top of antenna arrays, functioning well as transparent electrodes, says Sri Iyer.



Become a member of SIO Grafen

One membership, infinite possibilities.

As a member of SIO Grafen, you and your company get to be part of Sweden broadest, most up-to-date network in the ecosystem of graphene.

SIO Grafen's members are the country's front figures in the graphene area. As a member, you get to be involved in the programme and influence its direction.

Our membership include:

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- Opportunity to influence the programme's focus through voting rights at the Annual General Assembly
- Opportunity to be elected to board assignments
- Logo on SIO Grafen's website

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Anna Carlsson, Bright Day Graphene

Porous graphene structures for energy storage

Bright Day Graphene, Organic Electronics and RISE Bio have worked together to create a porous structure of BDGs graphene. They also aimed to test the structure as electrodes for supercapacitors, and as an anode for Lithium-Ion batteries. So far, the project has been successful in creating the porous structure and the structure as an electrode for a supercapacitor have been tested.

 It works way better than the previous material, but we want to optimise it a bit to reach the numbers we're looking for, says project leader Anna Carlsson, Bright Day Graphene.

Mats Sandberg, RISE

High-conducting 2D-material with "layer-by-layer deposition" (2D LbL)

RISE, 4EAntenna and Grafren developed new methods for creating highly conductive thin layers of 2D material with layer-by-layer deposition (LbL), to use particles coated with 2D material in electrically conductive adhesives.

 We have improved methods for producing Reduced Graphene Oxide (rGO) films by LbL of Graphene Oxide (GO) films using reactive counter
-ion. In addition, we found a simple and low-cost method for deposition of thick (hundreds of g / m2) GO and rGO coatings. Now, we are looking for partners to continue, says Mats Sandberg.

Patrik Lundin, APR Technologies

Streamlining heat exchanger for Stirling cryocoolers based on graphene

A regenerator is a type of porous heat exchanger for fluid flows with altering direction with the task of alternately absorbing and releasing heat from the working fluid as it travels back and forth through the regenerator. In this project, partners from 2D fab and APR Technologies have specifically been looking into Stirling Cryocoolers.

 We have been approved for a long extension.
We see progress with promising and interesting results, says project leader Patrik Lundin, APR Technologies.

Jiantong Li, KTH

Graphene-Enhanced Smooth Ceramic Coatings for High-Performance Electronics

KTH and Huawei Sweden have developed a graphene-based nanocomposite ceramic coating process to smoothen the surface of radiofrequency devices based on industrial ceramics, to improve their electrical performance.

- We have demonstrated that graphene nanocomposite ceramic coatings can reduce the surface roughness of the industrial ceramic devices by more than twice and are free from large cracks. In addition, with the coatings, the key performance (quality factor) of the ceramic resonators has increased by 11.5% at a low relative sample variance of only 1.7%, says Jiantong Li.

Feasibility studys







Manisha Phadatare, Mittuniversitetet

Microwave assisted synthesis of silicon graphene composites for high performance lithium-ion batteries

How can lithium-ion batteries become even more efficient? This challenge, partners from 2D fab, Percy Roc, Mittuniversitetet and Uppsala University took on.

 We are using silicon particles, which makes it possible to increase the capacity by ten times, says project leader Manisha Phadatare, Mittuniversitetet.

The group used a simple scalable thermal process for a graphene-silicon nanocomposite. The material has shown really good performance compared to commercially available batteries and the partners believe upscaling is possible.

Andreas Fall, RISE

GrafCoat – Graphenebased extrusion coating for paperboard

In GrafCoat, partners from 2D fab, Holmen and RISE collaborated to produce graphenebiopolymer composites with improved gas barrier performance.

– The goal is to develop masterbatches for extrusion coating of paperboard, says project leader Andreas Fall, RISE.

The group was able to mix graphene with thermoplastic starch, which was selected as the biopolymer matrix. By adding softeners to the composites, the right mechanical characteristics were obtained for allowing hot pressing into thin films.



Lars Nilsson, Lanark

"White graphene" for cement-based surface treatment applications

The increasing world demand for concrete and infrastructure materials was the incentive for this project, where partners from Akademiska Hus, Chalmers, Lanark, RISE, SHT Smart High Tech and Skanska participated.

 We used boron nitride as an alternative to graphene oxide for the purpose to protect infrastructure against chloride penetration, says project leader Lars Nilsson at Lanark.

The results show that only a low percentage of boron nitride can already generate good results.

Ting Yang Nilsson, RISE Flexible graphene pressure sensor for compression therapy

By using a graphene textile pressure sensor, Grafren and RISE IVF aims to provide a potential solution to the long-term medical issues of pressure dosing in compression therapy

 The scope is to verify the potential of a graphene textile 3D pressure prototype sensor in order

correctly measure the compression presses for sub-bandage-pressure and compression stocking for compression therapy, Ting Yang Nilsson, project leader at RISE explains.

The partners have verified that the textile sensor has good potential.



verify potential of a graphene textile 3D pressure protot ne sensor."

Feasibility studys



Johan Jersblad, Saab Barracuda New Generation of Graphene Coasted Textiles for Defence Applications

Electrically conductive textiles are of great importance for such industries as aerospace, energy, and national defense. This project seeks validation of the technical feasibility of graphene textiles developed by Grafren as a component for the products of Saab Barracuda.

- The lab phase is finished with A4 textile samples coated with graphene, with electrical

conductivity. The pre-production phase is ongoing, towards full width coating of textile roles. Disruptive innovation is expected if we are successful, where graphene will improve all material properties in a camouflage net, says Johan Jersblad.

"Disruptive innovation is expected if we are successful."

Feasibility studys

Jiantong Li, KTH

Supersonic spraying of graphene / MXene-based conductive durable coatings for electrification

Partners from ABB and KTH have fabricated electrically conductive wear-resistant coatings based on supersonic spraying of graphene/MXene.

– We have demonstrated that it is feasible to fabricate up to hundreds of microns thick graphene coatings on metal substrates. The coatings can reduce friction whereas the contact resistance could be further reduced, says project leader Jiantong Li, KTH.

The coatings can extend the lifetime of electrical contacts for various electrification and motion products.

Farid Akthar, HIPOR Materials

Stronger and more sustainable freeze-thaw resistant concrete

Project members HIPOR Materials, 2D fab, Nouryon, RISE, and SweRock focused on two types of raw materials: graphene and thermoplastic microspheres. Both types have the potential to increase the strength of freeze-thaw resistant concrete and reduce the amount of cement clinker used in the product. The reduction of cement clinker in concrete has a great impact on CO2 emissions.

 We evaluated two different grades of graphene in cement. We saw strength improvement both in compression strength and bending strength.
Graphene needs optimization, and better dispersion and wetting is required for optimized properties, says Farid Akthar.

Andrea Spanou, Graphmatech

Developing graphenepolymer composites for SLS printing applications

Graphmatech and Uppsala University are working on developing polymeric composites with graphene for Selective Laser Sintering (SLS) printing. To obtain a conductive powder for 3D printing electrically conductive parts, coating of SLS particles with the graphene was tested.

 We found some very good results and further tests are being carried out to fully identify graphene's contribution to the printing process.
Market analysis is underway to explore commercialization potential, says Andrea Spanou.

Stacy Trey, RISE

Smart Sealants with Graphene: Monitoring Properties with Eddy-Current Sensors

RISE, 2D fab and Trelleborg has the goal to develop a sealant that can be monitored in terms of mechanical properties correlating to sealing force, over time ideally without the need for electrodes. Samples will be made of ethylene propylene diene monomer (EPDM) rubber with a range of types and amounts of graphene and carbon black.

– Conductivity increased with more carbon black, we found signals even in the most non-conductive samples. It's very promising! The next step is to make new samples and replace carbon black with graphene flakes, says Stacy Trey.

Irma Heikkilä, Swerim

Graphene in amorphous metals for improved efficiency of components in electrical vehicles – G-Ame

New material solutions are of great interest for achieving an improved performance for the electrical system in electric vehicles. Here, Swerim, Exmet, Graphmatech and Inmotions checks the potential of graphene for achieving a tailored combination of magnetic and electric properties in amorphous components.

 We are evaluating right now. Iterative trials will be performed to identify the most potential functionalized graphene type and their content for the near net shape manufacturing of components, says Irma Heikkilä.

Govindan Induchoodan, Chalmers/Glenntex

GRECO - Green Earth, Clean Oceans

With the help of tailored graphene, Chalmers, Glenntex and Head teamed up to reduce the virgin-PET during recycling.

 This is basically a circular economy initiative, project leader Govindan Induchoodan, Chalmers, explains.

The partners have collected fishing nets and similar materials of various qualities from the ocean, and then combined them with tailored graphene.

 This helps compensating for the sometimes poor quality and makes it possible to regain missing and desired properties, in this case, in sports equipment.

Results show an impressing improvement of 50 percent.

Anwar Ahniyaz, RISE

Graphene-enhanced binder-free cathode formulation for nextgeneration lithium-ion batteries (GraFREE)

The traditional manufacturing process of batteries contains electrochemically inactive binders and conductive materials, which reduces the specific capacity and energy density of the active materials. When the binder and the conductive material are eliminated, the energy density of the battery can be largely improved. Here, RISE and Graphmatech propose a graphene enhanced NMP and



PVDF free cathode formulation for next generation lithium-ion batteries.

– Graphene do improve the batteries. Now we check out commercially available LFP powders and screen various types of Aros® graphene, says Anwar Ahniyaz.



We know graphene

We at the Programme Office are always willing to guide you through graphene and two-dimensional challenges. Don't hesitate to contact us for your next project. We are happy to share our expertise and advice.

Get in touch with us!

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Britta Andres, 2D fab

Graphene in sustainable adhesives

There are over 500 000 adhesives available on the market, but most of them aren't sustainable at all. Here, 2D fab and Pro&Pro wants to change that – with the use of graphene. The project aims to establish a strong corporate consortium that includes the entire value chain. – Graphene can enable a more efficient glue with new, better, and sustainable functions, says Britta Andres.

"Graphene can enable a more efficient glue with new, better, and sustainable functions."



Preparation projects

Tommi Remonen, Graphmatech

Green contacts

Worldwide, the need for electrification components is growing. The contact market where silver is one of the leading materials is expanding.

Contacts are becoming expensive due to shortage of metals in combination with a high demand.We want to be a part of a green revolution in this area, enhancing contacts with graphene and reducing metal material need, says project leader Tommi Remonen, Graphmatech.

The project aim at overcoming uncertainties related to the business role of key partners in the value chain for their proposed green approach to silver contacts.

Magnus Larsson, 2D fab

Graphene for resource-efficient rubber<u>materials</u>

Rubber, an irreplaceable nonrenewable material. In this project, 2D fab addresses the dilemma by adding graphene.

 It helps reduce the use of fossil materials while at the same time increase performance, project leader Magnus Larsson explains.

The goal was to identify the rubber material and the product that has the highest potential for a successful demonstrator project. So far, the market analysis has shown great results for all material and product candidates.

– The value chain will be key moving forward.

Emma Angehed, Bright Day Graphene

Porous graphene structures in energy storage

This preparation project aims to create a project consortium for a demonstrator project that involves porous graphene structures in energy storage. Bright Day Graphene has two main tracks. The first is the use of the porous structures as electrodes in supercapacitors. The second is about applying the porous graphene structures as anodes in lithium-ion batteries.

 This can help create environmentally friendly supercapacitors with high energy density, and make fast-charging lithium-ion batteries, says Emma Angehed.

Erik Khranovskyy, Grafren Ultralight, Soft and Breathable Graphene Textile Heaters

Grafren, Coxa Carry and Interactive Wear is in this prep activity for a future Demonstrator project. The aim is bringing

(Grapheat)

together a future consortium representing the separate links in the value chain of manufacturing and commercializing graphene textile heaters.

– Graphene textile heaters can be one of the earliest "genuine graphene" products with the potential to reach the market as early as 2022/23. It is thanks to the properties of the 2D graphene that such heaters are extremely light, soft, thin and let air and moisture through, says Erik Khranovskyy.

Christian Werdinius, Provexa Technology

Preparation project for GAIA - Grafen Application in Industrial Facility

Partners from Provexa AB, Provexa Technology, Chalmers Industriteknik and RISE IVF have collected results for making a targeted application for a demonstrator project (GAIA).

 We've put much effort in meetings with potential end customers to understand their needs for certain properties and to collect applicable standards, says Christian Werdinius, Provexa Technology.

GAIA aims to create a flexible automated pilot line adapted for graphene-containing processes, to upscale ongoing R&D projects and to create a basis for business development.



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Rewarding



What single word would you use to describe Swedish Graphene Forum 2021?

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

Source: Swedish Graphene Forum Survey 2021

