Report from the conference

Graphene Week 2018, San Sebastián

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FORMAS

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Summary

Every year, the Graphene Flagship organizes the Graphene Week conference, as part of one of the largest European conference series with a focus on graphene. The other is the Graphene 2018 series, on which we reported earlier this year. Both series are based on the academic/researcher's point of view. Although the Graphene Week conferences are aiming to move the focus increasingly toward industry, to reflect the evolution on tasks and objectives of the Graphene Flagship, research results and academic presentations are still the main focus of the conference. In the morning, more general, plenary presentations were given. In the afternoon, several parallel sessions focused on various topics were offered. On the first three afternoons, there was also a session dedicated to innovations with graphene. There was a small exhibition area where approximately 15 companies and organizations presented their products and prototypes.

More than 600 people from more than 40 countries attended. The full programme is available here: https://graphene-flagship.eu/grapheneweek/Pages/Programme.aspx

Plenary sessions

During the talks of the plenary sessions, even if the topics were very fundamental and approached mainly from an academic point of view, many of the speakers made connections with applications. Several speakers talked about large-scale integrations and requirements. There were also a number of talks where the focus was on other 2D materials, or on heterostructures made from 2D materials, reflecting an evolution in the focus of fundamental research.

Peter Bøggild, from the Technical University of Denmark, gave a presentation on the manufacture and metrology challenges for 2D materials, focusing on a newly developed technique to map the conductivity of graphene on wafer scale. This technique, terahertz time domain spectroscopy, can map the conductivity, mobility and relaxation time of carriers. It is non-destructive and can map an entire wafer in a matter of minutes. There is a lot of interest in this technique. Several other speakers mentioned it during the week and more than one company highlighted its importance.

Graphene Innovation Forum

The Graphene Innovation Forum, aimed to give a broad overview of the industrial applications of graphene, was well attended and generated valuable discussions.

The first session focused on **roadmapping** activities for applications using graphene and other 2D materials. The session was opened by Thomas Reiss, leader for the Graphene Flagship's Industrialisation work package, who highlighted work on the Technology and Innovation Roadmap. Antonio D'Errico gave a broad view on the future of telecom networks, and Blanca Guasch gave an overview of what interactive and collaborative product design involving different stakeholders looks like.

The second session focused on **standardisation**, where the importance of developing standards for graphene to enable its commercialisation was highlighted. This topic is getting more traction, underlining that it is key for industrialization. Norbert Fabricius, leader of Standardisation within the Graphene Flagship, highlighted the importance of documentary standards for accelerating graphene industrialization.

A representative from the United States' National Institute of Standards and Technology talked about diverse efforts around the world, like the Round Robin type activity and characterization guide, showing that the activities we put forward in SIO Grafen are well in line with global efforts to promote the utilization of graphene. There is already one standard on the vocabulary related to graphene and related 2D materials and several others are well on their way, reflecting a strong desire to create standards and characterization activities. One of the problems at the moment is that it is not always completely clear to know what to standardize, in the field of composite, for example.

During the third session, the Graphene Innovation Forum explored how to accelerate graphene and related 2D materials towards **commercialisation**. Francesco Bonaccorso presented one of IIT's spinoff, BeDimensional, which sells graphene powders, inks and pastes. Iñigo Charola, from Graphenea, talked about their recently developed new sensor platforms, with the goal to accelerate and facilitate entry of graphene-based sensors into the market - as well as simplify research projects based on a common platform. The presentation from Ken Verguts, IMEC, on challenges and opportunities of CVD graphene transfer process also generated many interesting questions and comments.

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Industrial Exhibition at Graphene Week

This year, SIO Grafen had a stand in the exhibition part of the conference and presented graphene innovation in Sweden. Nine different prototypes and demonstrator were showcased.

Applied Nano Surfaces (ANS) showed their graphene-based low-friction and - abrasion coating (Tricolit-GO!), as well as a piece of metal showing how the coating looks once applied and cured. The spray can be used for improving the tribological properties in various applications. The spray is applied to the surface like a regular paint and is heat-cured afterwards.

ANS have conducted the project *Nano coal coating*, financed by SIO Grafen, together with Epiroc, Trelleborg och Dalarnas högskola in order to develop a graphene fortified low friction coating, that features low friction and low abrasion resistance. The project was finalised in the spring of 2018, and a few months later, the results were commercialised in the form of the spray Tricolit-GO!.

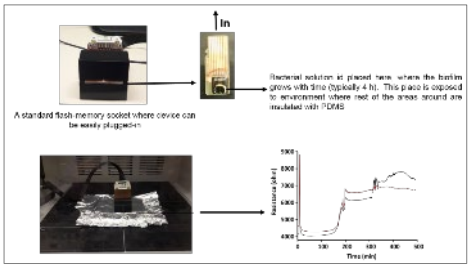
APR Technologies (APR) showed their working prototype of a miniaturized cryo cooling compressor based on graphene. By using graphene in a small and compact cooling pump without moving parts, electronic systems should be able to cool down to ultra low temperatures. The project *Miniaturized cryo cooling based on graphene*, financed by SIO

Grafen, is a continuation of a previous project collaboration between APR, SHT Smart High-Tech and Chalmers. The goal is to develop a small vibration-free graphene-based compressor without moving parts, powered by thermal energy. The project ends in 2019.

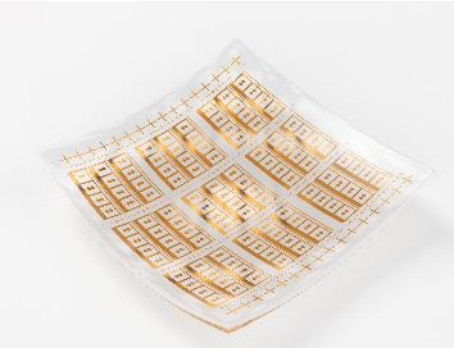
2D fab is a supplier of customized graphene and electrically conductive flexographic printing inks. The produce graphene flakes.

2D fab showcased graphene enhanced polycarbonate pellets for use in composite applications and impact demanding applications. There was a lot of interest in this product. 2D fab is currently involved in seven projects within SIO Grafen (four have been finalised earlier).

From Chalmers University of Technology, there were several demonstrators. A group of researchers led by Ivan Mijakovic presented an antibacterial coating, as well as a bio sensor platform based on graphene. Chalmers and Dentsply IH AB (Wellspect Healthcare), have carried through the project *Graphene layers to prevent catheter related urinary infection,* financed by SIO Grafen. The project has given in-depth knowledge of why certain forms of graphene are antibacterial, while graphene in other forms do not affect bacteria (or other cells) whatsoever. In order to commercialize the patented results, a cost-effective manufacturing method is required.



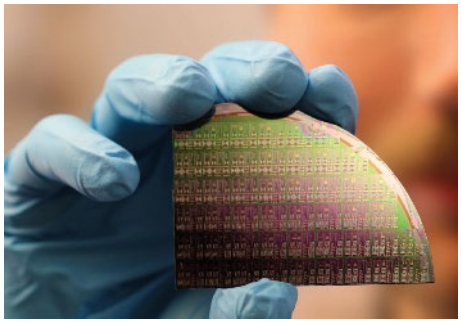
This work continues in the project *Polymers with exposed graphene edges: New antibacterial materials for medical device applications,* together with Dentsply IH/Astra Tech, Chalmers and 2D fab. A layer of vertical graphene flakes forms a protective surface that makes it impossible for bacteria to attach. Instead, bacteria are sliced apart by the sharp graphene flakes and killed. Coating implants with a layer of graphene flakes can therefore help protect the patient against infection, eliminate the need for antibiotic treatment, and reduce the risk of implant rejection.



Jan Stake's group sent a flexible graphene terahertz detector as well as a millimetre-wave receiver working at 200GHz.

Graphene combines flexibility and high frequency response for new powerful electronics systems. Terahertz sensors open up new possibilities in wireless sensor networks, unique imaging characteristics (night vision, for seeing through rain, snow, and fog), wearable devices and smart clothing.
The KTH Royal Institute of Technology also presented several applications. Researchers from Mikael Östling's group showcased a full wafer of graphene-based sensors.

There is a critical need for fast, low-cost biosensing in low-volume blood samples that gives immediate results. The sensing platform developed by KTH is based on silicon photonics with graphene photodetectors which identify the "molecular fingerprint" in the



infrared spectrum of disease indicators in a single drop of blood from a prick in the fingertip. Graphene provides the ability of low-cost, high-volume integration with established silicon photonics platforms - a unique combination competing technologies lack. The direct electrical readout enables the exchange of information over existing telecommunication infrastructure and supports the early identification of epidemic outbreaks and the coordination of humanitarian aid. KTH has implemented a similar project within SIO Grafen, *Waveguide-Integrated Graphene Based mid-Infrared Detectors for Optical Gas Sensor Chips*.

Jiantong Li used inkjet printing with graphene ink, to produce a piece of metal with the logos of KTH and SIO Grafen. There was a strong interest in this demonstrator.
In 2015-2016, KTH and XaarJet AB (Xaar) collaborated in the project *iEnergy - Industrialization of inkjet printing technology with graphene for energy storage applications,* financed by SIO Grafen. KTH was scaling up their fabrication technique for graphene inks and XaarJet was testing the inks' printability. The project verified the capability of industrial-scale inkjet printing of graphene. KTH spun off an ink company, Aninkco AB, for further development and sales of high-quality graphene inks.

Graphmatech, another Swedish company developing products with graphene, also presented their graphene product in their own booth. There was also great interest in their products. Graphmatech is involved in two projects financed by SIO Grafen, *Aros Graphene-baserade termiska interfacematerial* and *Självsmörjning och självkylning av polymer – Aros Graphene-kompositer*.