

EUROPE'S LEADING GRAPHENE CONFERENCE

GRAPHENE

MAGAZINE 2018

WEEK

ZERO-GRAVITY GRAPHENE
PHONE OF THE FUTURE
BIODEGRADABLE GRAPHENE
GRAPHENE FLAGSHIP ROUNDS
THE HALFWAY MARK



GRAPHENE FLAGSHIP



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GRAPHENE FLAGSHIP

THE GRAPHENE FLAGSHIP SCHOOL FOR EARLY CAREER RESEARCHERS

GRAPHENE

3-8 FEBRUARY 2019, OBERGURGL, AUSTRIA

STUDY

WINTER



Science and Technologies of 2D Materials



Lectures by key experts



Workshops and group activities



Excellent networking opportunities



Poster sessions



www.graphene-flagship.eu

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FROM THE EDITOR

Welcome to the first edition of the Graphene Week magazine. Over the years Graphene Week has grown to be more than just a graphene conference. It is an expression of the Graphene Flagship's accomplishments both in the form of scientific achievements and as the definitive source for information about the graphene universe: from the lab to industrial applications.

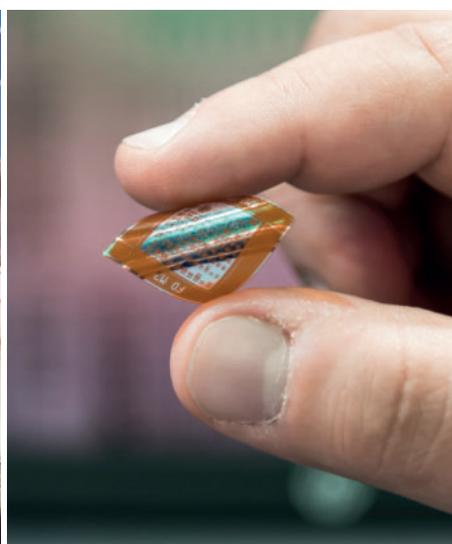
While Graphene Week's presentations, workshops, exhibition and other events come together in a collage presenting the many pieces that make up the Graphene Flagship, this magazine seeks to fill in the gaps. The Graphene Flagship is much more than its individual pieces. Collaboration and a broader purpose allow the individual efforts, presented at Graphene Week, to transcend to another level. Taken together they can transform industries, touch lives and maybe even change the world as we know it.

So, take a step back from your corner of the graphene universe and take a moment to look at the bigger picture. See how we all fit into the larger whole, and consider how your conversations, interactions and presentations this week can influence the course of graphene research and innovation. What will be your takeaway? Perhaps a new collaboration, a new direction or even a new inspiration?

Don't let the networking stop here. Keep in touch with the Graphene Flagship community all year through our social media channels!

REBECCA WATERS

Graphene Flagship Communications Officer



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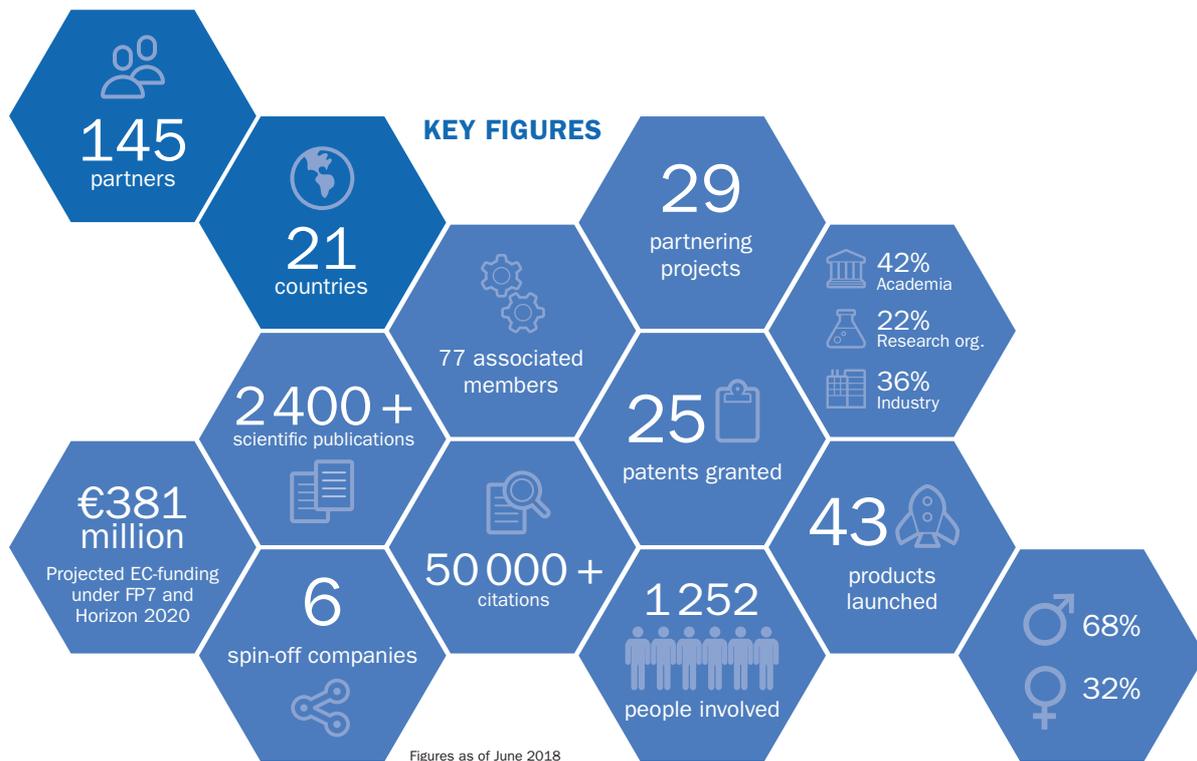
Henrik Eidegård

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GRAPHENE FLAGSHIP ROUNDS THE HALFWAY MARK

The Graphene Flagship has much to celebrate and a great deal to look forward to as it rounds the halfway mark and enters the third phase of the ten-year, European Commission funded initiative to bring together academic and industrial researchers and take graphene and related materials from the realm of academic laboratories into European society, generating economic growth, jobs and opportunities.

“The final review of the first core project confirms that the Graphene Flagship is well on track to reach its ambitious goals,” says Graphene Flagship Director Jari Kinaret.

The EC released the results of its review in August following an extensive look at reports and presentations from Graphene Flagship leadership as well as a demonstration of over 20 graphene product prototypes. The reviewers commended the Graphene Flagship for effectively transforming individual research initiatives into a “genuine collaboration towards larger goals” and cited a number of scientific and technical achievements as evidence that the project is moving in the right direction.

“Graphene and related materials are at the centre of an ever-increasing number of initiatives worldwide. With thousands of materials available that can be combined amongst them-

selves, there is an almost endless set of possibilities available for future investigation,” says Graphene Flagship Science and Technology Officer Andrea Ferrari. “The Graphene Flagship continues to study the properties and uses of these new materials and materials combinations, leading to the development of both new science and new applications.”

In fact, the output of the Graphene Flagship project is quite formidable. From the start of the flagship, consortium members have published over 2,400 scientific papers which have been cited more than 50,000 times. In addition, they have been granted 25 patents related to the Graphene Flagship and launched six new companies. Of the 43 graphene-related products that have been introduced to the market, most are different types of graphene materials or formulations. The technology has been maturing and higher value products such as products utilizing graphene composites and graphene-based photodetectors are being launched.

As demonstrated by its publication output and patent portfolio, the Graphene Flagship is defining the international forefront in its field. Its output includes, for instance, new ways to produce two-dimensional materials and their heterostructures, record-breaking photodetectors, novel sensors, next generation energy storage solutions and advanced composites for

uses in aerospace applications. Further details can be found in the Graphene Flagship's annual reports available at www.graphene-flagship.eu/annual-reports.

Other notable graphene successes include: work towards a high-speed photonic switch for 5G communication technologies, the leading edge of the horizontal rear stabilizer of an Airbus 350 and artificial retina implants to allow blind patients to recover some degree of vision.

Furthermore, a serendipitous discovery by researchers in the Health and Environment Work Package that few-layer graphene flakes kill monocytes—a type of immune cell responsible for one type of leukemia—could lead to a new type of cancer therapy.

Composites applications are among the most mature markets for graphene, with several commercial products already available from Graphene Flagship partners. More recently, products are being launched in other areas as well. For example, based on research conducted within the Graphene Flagship framework, Emberion launched a fully packaged photodetector module that can detect light in the visible to short-wave infrared ranges. Aimed at industrial applications including spectrometry, gas detection and power measurements, the low-noise, high-sensitivity detectors are now available for Emberion's customer base. This product is the Flagship's first commercial launch exploiting graphene's unique electro-optical properties.

PUBLIC OUTREACH

Graphene Flagship events have played a key role in increasing awareness of graphene among academic communities, indus-

tries and the general public. Graphene Week, Europe's leading graphene conference, provides a venue for researchers to present their findings and industry representatives to exhibit their work in the field of graphene and related two dimensional materials. The event, now in its 13th year, attracts 700 participants from 45 countries worldwide and features 190 expert presentations.

Each edition of Graphene Study, the Graphene Flagship's school for early career researchers, aims to bring together students working on related areas of research with experienced scientists from academia and industry, helping to shape the future of graphene.

The Graphene Flagship is actively engaging in the education of future experts in graphene and related technologies. To this extent, the project has hired over 300 graduate students that are trained by the Flagship and after graduation will take their expertise to European industries, further strengthening the knowledge transfer between academia and industry.

THE FUTURE

"Research cannot be planned in detail, and we must always maintain a basic research component even when the centre of gravity of the Graphene Flagship moves to higher technology readiness levels," Kinaret says. "This said, in the coming years the Flagship must increasingly focus on those areas where it has the highest potential to create positive impact in Europe. We must rely on our combined expertise and place our bets to maximize the payoff to our funders, the European tax-payers."



BEHIND THE SCENES

ON HER LAST DAY KATARINA BOUSTEDT DISCUSSES HER FLAGSHIP LIFE

By Siân Fogden



Katarina Boustedt joined the Graphene Flagship on the day it launched—1 October 2013. Her role was truly unique, to manage a project that started with 75 partners. She was instrumental in developing the Graphene Flagship into the sophisticated project we see today. Five years later, as she leaves the Flagship to

move on to her next exciting challenge, we talk to Katarina about why she joined the Flagship, what she has achieved during this time and her hopes for the future.

SF: How did you get involved with the Graphene Flagship in the first place?

KB: My route to joining the Graphene Flagship was not what you would expect. I read in the Swedish newspaper, *Göteborgs-Posten*, about a big European Union project coming to Chalmers and thought it sounded extremely interesting. I was working for Ericsson Research as a senior researcher at the time, but as Ericsson was moving from focusing on hardware to software, I was looking for a new challenge. So, I contacted Jari Kinaret (the Director of the Graphene Flagship) and simply said, 'you're going to need a good project manager, here I am.' Although at this point Jari had not considered the role, I convinced him that to run a project of this size, an experienced project manager would be essential. They recruited for the post, and happily I was chosen because of both my project management skills and my industrial expertise.

SF: Managing an EC project of this size must have been quite a feat – how did it start and evolve over time?

KB: With a project this big, all of the partners had lots of questions. With no written procedures in place, my job started with many many phone calls from the partners. We soon realised that it was completely infeasible to interact with the partners this way—they had to be able to get the information they required for themselves without needing to speak to us. This started very simply with a procedural document that was uploaded to a read only folder which was the early days of what would become the Graphene Flagship intranet—called Onboard. In these early days I worked very hard to find a system that could support the full 10-year lifespan of the project and it has been an invaluable tool for the management of the Graphene Flagship.

Over time the importance of this work was realised and I was made Head of Administration and leader of the work package on Research Management. This held three cross-work package tasks: characterisation and standardisation of graphene, roadmap, and the Samples and Materials Database. This work package then became the industrialisation work package. As the Flagship moves forward in its goal of commercialising graphene, it is important to emphasise the industrialisation work and clearly establish it as a cross-work package initiative to make sure that industry is the driver for commercialisation.

SF: You have been instrumental in setting up the Graphene Flagship as it is today. Why did you decide to leave at this point and what are your hopes for the Flagship as you depart?

KB: It's been a very challenging five years working for the Flagship, setting up all the processes and procedures for such a big project has been an all-consuming task. However, things are up and running now and honestly there is not much more I can do in this position. As there is nowhere I can advance to in the Flagship structure it's the perfect time to move on to something new. As I leave the Flagship, I hope that its commercialisation goal is successful and graphene is really put to use.

SF: You also set up the very successful Women in Graphene network, where did the idea come from and how do you hope it will evolve?

KB: Within the Graphene Flagship it was obvious from the start that there are quite a lot of women involved. However, the women were mostly in the earlier stage of their careers and I had a feeling that they were not in focus as much as they should be. I wanted to make sure that all the women working in the Flagship had the network and connections they needed to succeed.

I realised pretty soon that we needed separate meetings, I wanted to give women who may have less of a voice in their current work a place to meet, make connections and hear from other women who are doing and have done fantastic things in their careers. We now have a session at Graphene Week every year, along with a career development stand-alone day which I hope will go some way to achieving this goal. As I hand this group over, I really hope that my vision of a Graphene Flagship mentoring scheme will be realised to make sure that all young researchers have the support that they need to succeed.

ZERO-GRAVITY GRAPHENE

By Siân Fogden

In a successful collaboration between the Graphene Flagship and the European Space Agency (ESA), experiments testing graphene for two different space-related applications have shown promising results. Based on these results, the Graphene Flagship is continuing to develop graphene devices for use in space.

LOOP HEAT PIPES

After initial experiments performed in zero-gravity conditions to investigate if graphene's thermal properties could improve the performance of loop heat pipes, (the thermal management systems used in aerospace and satellite applications), research continues to move forward within the Graphene Flagship.

"Graphene has many opportunities for applications. One of them, recognised early on, is space technology. The Graphene Flagship, with the leading contribution of aerospace industry partner Leonardo, has demonstrated the viability of graphene for thermal management in space. The plan during Core 2 is to progress it further for tests to be then conducted on a spacecraft," said Andrea Ferrari, science and technology officer of the Graphene Flagship and chair of its Management Panel.

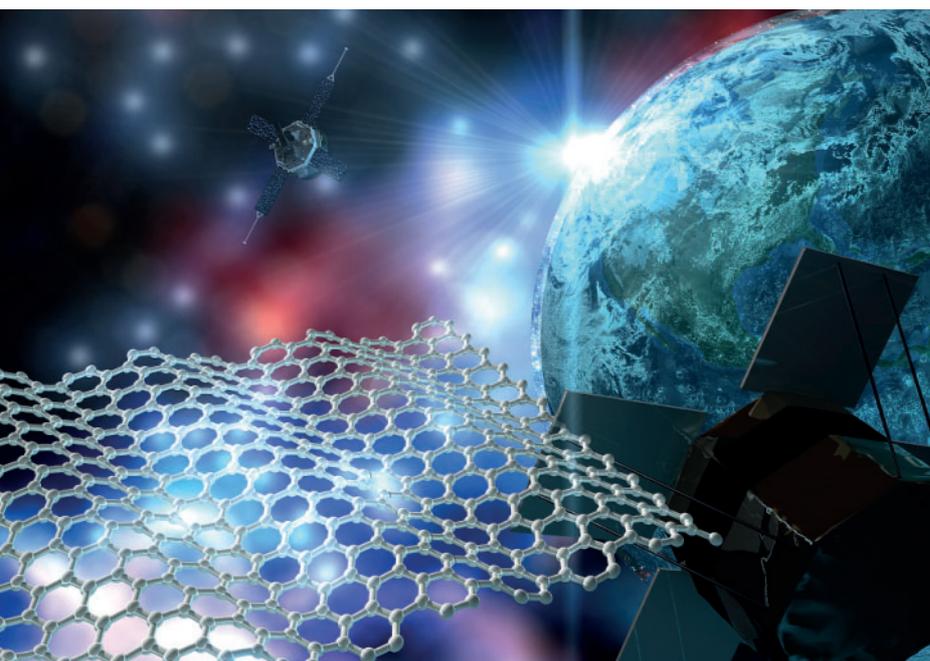
The researchers are now moving from proof of concept to a true to scale working device using the graphene coated wick.

The wick is the main element in the loop heat pipes where heat is transferred from a hot object into a fluid, which cools the system.

"We were very pleased to find that the measurements we took during the parabolic flight campaigns demonstrated that graphene has a positive effect on the evaporation rate through the wicks. Since then we have been performing further experiments to understand the reasons for this improvement whilst also working on scaling up the graphene coatings to industrial-wicks, like the ones on satellites and spacecraft," said Meganne Christian, a researcher at the National Research Council of Italy (CNR) and part of the loop heat pipe team.

"This is a great example of how the Flagship is working: bringing together three academic partners and one big industrial partner with a clearly defined goal for an application," said Vincenzo Palermo, vice-director of the Graphene Flagship.

"For a company like Leonardo, innovation is vital: we put great expectations in the industrialisation of graphene-based products. Thanks to the Flagship the introduction into market can be significantly accelerated, as for the loop heat pipe," says Marco Molina, chief technical officer of space activities at Leonardo.



Graphene has huge potential for applications in space technology



Meganne Christian enjoying zero-gravity during the parabolic flight

The graphene wicks were tested in a collaboration between the Microgravity Research Centre, Université libre de Bruxelles, Belgium; the Cambridge Graphene Centre, University of Cambridge, UK; the Institute for Organic Synthesis and Photo-reactivity and the Institute for Microelectronics and Micro-systems, both at the National Research Council of Italy (CNR) and industry partner Leonardo Spa, Italy, a global leader in aerospace, operating in space systems and high-tech instrument manufacturing and in the management of launch and in-orbit services and satellite services. To test the graphene-coated wicks in microgravity conditions, the researchers took part in 6 parabolic flights in November and December 2017 which were operated by ESA in partnership with Novespace.

SOLAR SAILS

Testing graphene space-propulsion potential, a team of PhD students from Delft Technical University (TU Delft), The Netherlands participated in ESA's Drop Your Thesis! campaign, which offers students the chance to perform an experiment in microgravity at the ZARM Drop Tower in Bremen, Germany. To create microgravity conditions, down to one millionth of the Earth's gravitational force, a capsule containing the experiment is catapulted up and down the 146 metre tower, leading to 9.3 seconds of weightlessness. The TU Delft Space Institute, The Netherlands, also provided support to the GrapheneX project.

The team—named GrapheneX—designed and built an experiment to test graphene for use in solar sails, using graphene membranes provided by Graphene Flagship partner

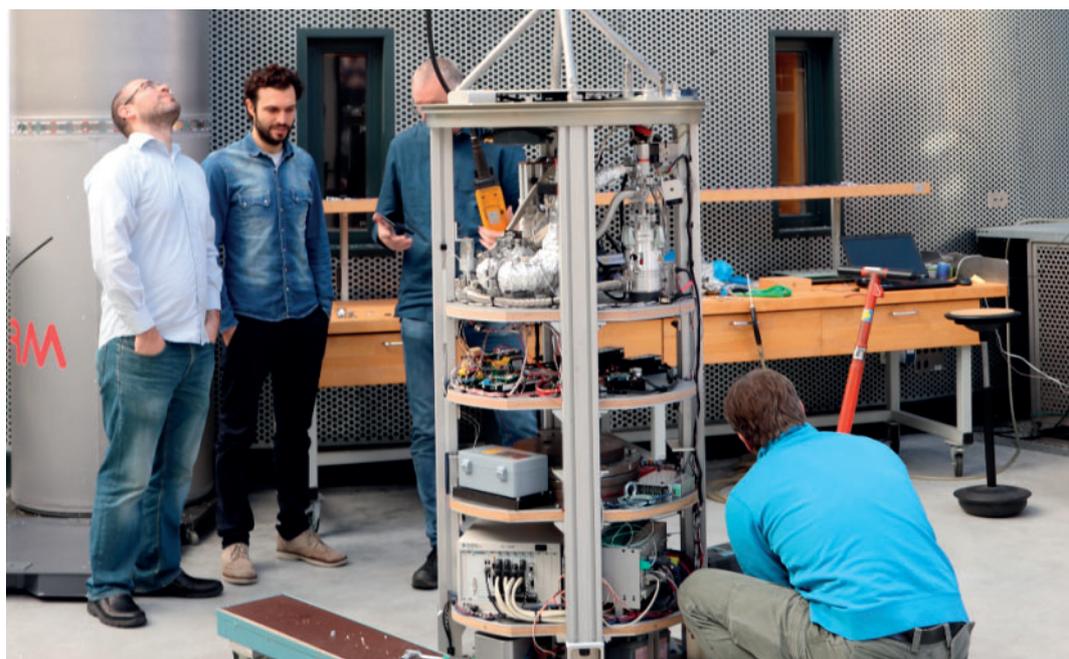
Graphenea. The idea was to test how these would behave under radiation pressure from lasers. In total, the experiment ran five times over 13-17 November 2017.

“Our experiment is like a complex ‘clockwork’ where every component has to go off seamlessly at the right time,” said Rocco Gaudenzi, a member of the GrapheneX team, “it does not often happen that you have to build up such a clockwork from scratch, and you can only test it during the launch itself.”

The team worked hard to make the experiment successful. “Despite the initial technical difficulties, we managed to quickly figure out what was going on, fix the issues and get back on track. We are very happy with the results. We observed laser-induced motion of a graphene light sail, and most importantly we had a great experience!” said Davide Stefani, GrapheneX team member.

Santiago J. Cartamil-Bueno, GrapheneX team leader, indicated that both the experience and the results were valuable to the team. “The most important lesson is that something will always happen, and you need to be ready to adapt or to change,” he said. “I think at the end of the day, it is about the experience; you just need to create new challenges and learn from them, and be ready to grab more experience and go to the next level.”

Though the GrapheneX experiment is now finished, the team is planning further tests as part of a new and ambitious research project, to continue exploring the influence of radiation pressure on graphene light sails.



The GrapheneX team make final adjustments to their solar sail experimental capsule

GRAPHENE FOR HUMAN SPACE EXPLORATION

15:30-18:15
MONDAY, 10 SEPTEMBER

14:30-18:00
TUESDAY, 11 SEPTEMBER

This workshop, organised jointly with the European Space Agency, is intended to create a multidisciplinary ecosystem for exploring potential applications of graphene in support of human exploration in space. The primary focus is on life support systems with a distinctive focus on tissue healing in extreme environments.

It will represent a unique environment where scientists of different disciplines could join to discuss and integrate the existing challenges and the solution strategies.

GRAPHENE SQUEEZES LIGHT TO ONE ATOM

By Alina Hirschmann and Siân Fogden

In a study published in *Science*, researchers at ICFO – The Institute of Photonic Sciences in Barcelona, Spain, along with other members of the Graphene Flagship, reached the ultimate level of light confinement. They have been able to confine light down to a space one atom, the smallest possible. This will pave the way to ultra-small optical switches, detectors and sensors.

Light can function as an ultra-fast communication channel, for example between different sections of a computer chip, but it can also be used for ultra-sensitive sensors or on-chip nanoscale lasers. There is currently much research into how to further shrink devices that control and guide light.

New techniques searching for ways to confine light into extremely tiny spaces, much smaller than current ones, have been on the rise. Researchers had previously found that metals can compress light below the wavelength-scale (diffraction limit), but more confinement would always come at the cost of more energy loss. This fundamental issue has now been overcome.

“Graphene keeps surprising us: nobody thought that confining light to the one-atom limit would be possible. It will open a completely new set of applications, such as optical communications and sensing at a scale below one nanometer,” said Frank Koppens at Graphene Flagship partner ICFO, who led the research.

This team of researchers including those from ICFO (Spain), University of Minho (Portugal) and the Massachusetts Institute of Technology (USA) used stacks of two-dimensional materials, called heterostructures, to build up a new nano-optical device. They took a graphene monolayer (which acts as a semi-metal), and stacked onto it a hexagonal boron nitride (hBN) monolayer (an insulator), and on top of this deposited an array of metallic rods. They used graphene because it can guide light in the form of plasmons, which are oscillations of the electrons, interacting strongly with light.

“At first we were looking for a new way to excite graphene plasmons. On the way, we found that the confinement was stronger than before and the additional losses minimal. So we decided to go to the one atom limit with surprising results,” said David Alcaraz Iranzo, the lead author from ICFO.

By sending infra-red light through their devices, the researchers observed how the plasmons propagated in between the metal and the graphene. To reach the smallest space conceivable, they decided to reduce the gap between the metal and graphene as much as possible to see if the confinement of light remained efficient, i.e. without additional energy losses. Strikingly, they saw that even when a monolayer of hBN was used as a spacer, the plasmons were still excited, and could propagate freely while being confined to a channel of just one atom thick. They managed to switch this plasmon propagation on and off, simply by applying an electrical voltage, demonstrating the control of light guided in channels smaller than one nanometer.

This enables new opto-electronic devices that are just one nanometer thick, such as ultra-small optical switches, detectors and sensors. Due to the paradigm shift in optical field confinement, extreme light-matter interactions that were not accessible before can now be explored. The atom-scale toolbox of two-dimensional materials has now also proven applicable for many types of new devices where both light and electrons can be controlled even down to the scale of a nanometer.

Andrea C. Ferrari, science and technology officer of the Graphene Flagship added, “While the Flagship is driving the development of novel applications, in particular in the field of photonics and optoelectronics, we do not lose sight of fundamental research. The impressive results reported in this paper are a testimony to the relevance for cutting edge science of the Flagship work. Having reached the ultimate limit of light confinement could lead to new devices with unprecedented small dimensions.”

Reference:

Probing the Ultimate Plasmon Confinement Limits with a van der Waals heterostructure

David Alcaraz Iranzo, Sebastien Nanot, Eduardo J. C. Dias, Itai Epstein, Cheng Peng, Dmitri K. Efetov, Mark B. Lundeberg, Romain Parret, Johann Osmond, Jin-Yong Hong, Jing Kong, Dirk R. Englund, Nuno M. R. Peres, Frank H.L. Koppens

Science, DOI 10.1126/science.aar8438 (2018)

GRAPHENE

WEEK

Programme 2018



GRAPHENE FLAGSHIP



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WELCOME

On behalf of the Graphene Flagship, I wish to welcome you to the 13th edition of Graphene Week. I hope you enjoy the Conference and your time in beautiful San Sebastian. The city, long known as a tourist destination, is now also becoming known as a city of science and technology, with new research centres, first-class scientists from around the world and the support of strong industrial activity in the region.

The fundamental science behind graphene and other two-dimensional materials is key at Graphene Week—as it helps to explore new concepts that will lead to the applications of the future—but there will also be a focus on applied science (electronic devices, sensors, flexible electronics, biomedical applications, composites, energy storage, etc.) and on graphene for a sustainable future, including renewable energies.

Graphene Week will include talks from 30 keynote and invited speakers, 95 oral presentations across three parallel sessions, four fringe sessions, over 300 poster contributions, a Graphene Innovation Forum and an Exhibition area.

A special effort has been made this year to combine an excellent program, including speakers from all over the world, with the organization of specific workshops including Graphene for Human Space Exploration, Women in Graphene and a US-EU Workshop on 2D Materials.

We hope you enjoy this opportunity to learn about the latest advances in graphene and other two-dimensional materials and to network with your peers, opening the door to new collaborations and exciting new research.

Thank you for joining us in San Sebastian!



JOSE M. PITARKE
Conference Chair
Director of nanoGUNE



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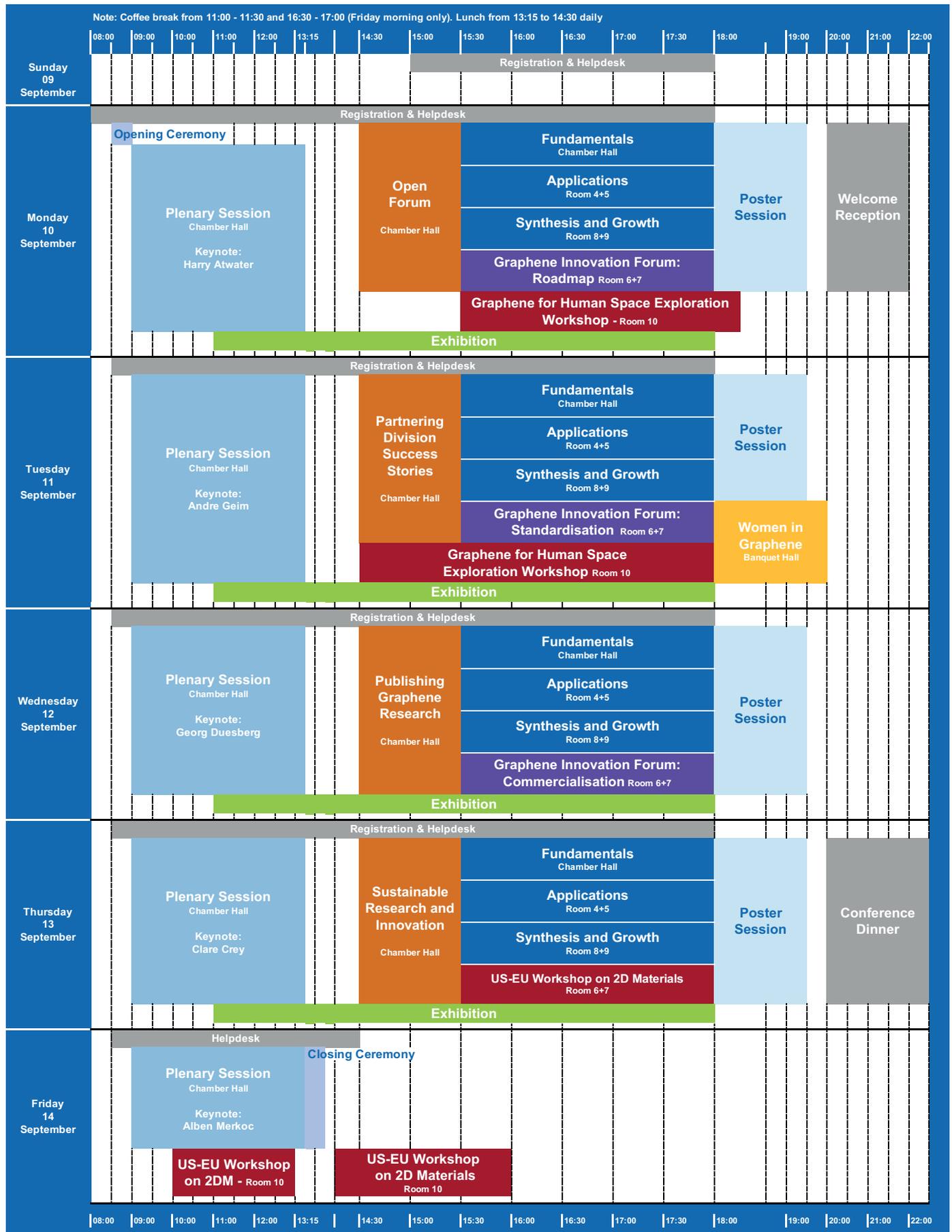
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Graphene Week 2018 - Programme Overview



SUNDAY 9 SEPTEMBER

15:00–18:00

REGISTRATION & HELPDESK

MONDAY 10 SEPTEMBER

07:45–18:00

REGISTRATION & HELPDESK

08:30–09:00

OPENING CEREMONY – Chamber Hall

JOSE MARIA PITARKE Chair of Graphene Week 2018

JARI KINARET Director of Graphene Flagship

JEAN-FRANÇOIS BUGGENHOUT Head of FET Flagships Unit at DG CONNECT, European Commission

MARKEL OLANO President of the Regional Council of Gipuzkoa

IÑIGO URKULLU President of the Basque Government

11:00–18:00

EXHIBITION – Exhibition Hall

09:00–13:15

PLENARY SESSION – Chairs: Javier Aizpurua and Jong-Hyun Ahn – Chamber Hall

09:00 HARRY ATWATER Tunable light-matter interactions in graphene

09:50 FRANK KOPPENS Quantum nano-devices and polaritons heterostructures 2D materials

10:25 DMITRI BASOV Plasmon polaritons in twisted bilayer graphene

11:00 Coffee in the Exhibition

11:30 XIADONG XU Moiré-excitons in MoSe₂/WSe₂ heterobilayers

12:05 AMALIA PATANE From epitaxy to science and processing technologies of novel van der Waals crystals

12:40 KIRILL BOLOTIN Bending, pulling, and cutting wrinkled two-dimensional materials

13:15–14:30

LUNCH IN THE EXHIBITION HALL

14:30–15:30

FRINGE SESSION I: OPEN FORUM – Chamber Hall

Learn more about the Graphene Flagship project and creating joint networking possibilities.

Speakers: JARI KINARET

KARI HJELT

Panellists: JEAN-FRANÇOIS BUGGENHOUT

AMAIA ZURUTUZA

FABRIZIO TUBERTINI

MEGANNE CHRISTIAN

Moderator: ZUBEROA MARCOS

15:30–18:00

PARALLEL SESSION I: FUNDAMENTALS – Chairs: Luis Hueso and Deji Akinwande – Chamber Hall

15:30 MIGUEL M. UGEDA Observation of Topologically Protected States at Crystalline Phase Boundaries in Single-layer WSe₂

15:45 ROSHAN K. KUMAR Electron Hydrodynamics in Graphene: Introduction and Status

16:00 VITOR PEREIRA Reproduction of the charge density wave phase diagram in 1T-TiSe₂ exposes its excitonic character

16:15 KRISTEN KAASBJERG Unprecedented transport properties of monolayer TMD devices: Experiment and theory

16:30 Coffee in the Exhibition

17:00 SABINA CANEVA Mechanically controlled quantum interference in graphene break junctions

17:15 ROMAIN DANNEAU Confining superconductivity in graphene bilayers

17:30 STEFAN BROMLEY Post-graphene organic Dirac materials with tunable spin-polarised and closed-shell semiconducting states

17:45 KISUNG CHAE Two-Dimensional T3X (T=C, Si, Ge, Sn; X=O, S, Se, Te) Compounds with Tetrahedral Bonding

15:30–18:00 **PARALLEL SESSION II: APPLICATIONS – Chairs: Rainer Hillenbrand and Amalia Patane – Rooms 4+5**

- 15:30** **SIMONE SCHULER** Graphene photodetector based on a photonic crystal defect-waveguide
- 15:45** **DMITRI EFETOV** High-speed bolometry based on Johnson noise detection of hot electrons in cavity-coupled graphene
- 16:00** **SEBASTIAN CASTILLA** High-speed and highly sensitive detection of terahertz radiation using photo-thermoelectric effect in high mobility graphene
- 16:15** **ARTUR MOREIRA-PINTO** Graphene inks for printing of flexible and stretchable electronics
- 16:30** Coffee in the Exhibition
- 17:00** **EVGENIYA LOCK** Novel graphene functionalization leading to ultrasensitive, robust and fast sulfur contaminants detection in aviation fuels
- 17:15** **RAIVO JAANISO** Graphene-based electronic nose for outdoor air quality
- 17:30** **PETER STEENEKEN** Graphene pressure sensors: concepts and challenges
- 17:45** **PAUL CAMPBELL** Use of two-dimensional transition metal dichalcogenide films for rapid and sensitive detection of hazardous chemical vapors

15:30–18:00 **PARALLEL SESSION III: SYNTHESIS AND GROWTH**
Chairs: Amaia Zurutuza and Mar Garcia Hernandez – Rooms 8+9

- 15:30** **YUYOUNG SHIN** Liquid-phase exfoliation of graphene in water using positively charged pyrene derivatives
- 15:45** **PABLO ARES** Isolation of highly stable antimonene under ambient conditions
- 16:00** **ANTONIO E. DEL RIO** Bridging the gap between lab and industrial scale production of 2D crystals
- 16:15** **PIOTR KAMEDULSKI** The synthesis of CNT-graphene composite
- 16:30** Coffee in the Exhibition
- 17:00** **MAURO OCH** High-Mobility and High-Optical Quality Atomically Thin WS₂
- 17:15** **HSUAN-AN CHEN** Selective growth and contact resistance reduction of Single-Crystal Antimonene prepared by molecular beam epitaxy on MoS₂
- 17:30** **NEERAJ MISHRA** Scalable metal-free CVD growth of graphene on sapphire
- 17:45** **VITALY BABENKO** Routes to high quality h-BN material by CVD

15:30–18:00 **GRAPHENE INNOVATION FORUM: ROADMAP – Chair: Francesco Bonaccorso – Rooms 6+7**

- 15:30** **THOMAS REISS** Identifying promising Graphene applications using the Graphene Flagship Technology and Innovation Roadmap
- 15:50** **LIJUN YIN** Chinese Graphene Industry and Graphene Products Certification
- 16:10** **PAOLO BONDAVALLI** Spray-gun deposition method for nanomaterials. Implementation for large impact applications
- 16:30** Coffee in the Exhibition
- 17:00** **ANTONIO D'ERRICO** The Sustainable Roadmap in ICT Leveraging on Graphene
- 17:20** **ANTONIO CORREIA** Graphene and 2D Materials EUREKA Cluster: Fostering European Competitiveness
- 17:40** **BLANCA GUASCH** Innovation as a Key Factor for the Development of Commercial Products with Graphene

15:30–18:15 **GRAPHENE FOR HUMAN SPACE EXPLORATION WORKSHOP**
Chairs: Carlo Saverio Iorio, Monica Monici, Lucia Delogu, Alberto Bianco – Room 10 B+C

- 15:30** **JASON P. HATTON** The European Space Agency programme for Human Space Exploration
- 16:00** **DENIZ BETEN** NATO Science for Peace and Security Programme
- 16:30** Coffee in the Exhibition
- 17:00** **LUCIA LOMBARDI** Graphene strain sensors
- 17:15** **VANJA MISKOVIC** Alginate-graphene oxide composites for applications in biosensors: wettability and mechanical properties
- 17:30** **FELICE STROLLO** Insulin resistance as the possible link between microgravity and impaired wound healing
- 17:45** **GEMMA RIUS** Graphene potential in extreme conditions founded on multidisciplinary methods and micro nanotechnologies
- 18:00** **SANTIAGO CARTAMIL-BUENO** Laser-induced propulsion of graphene lightsails in microgravity

18:00–19:30 **POSTER SESSION 1**

20:00–22:00 **WELCOME RECEPTION**

TUESDAY 11 SEPTEMBER

08:00–18:00	REGISTRATION & HELPDESK
11:00–18:00	EXHIBITION – Exhibition Hall
09:00–13:15	PLENARY SESSION – Chairs: Annick Loiseau and M. Pilar López-Sancho – Chamber Hall 09:00 ANDRE GEIM Electron hydrodynamics and Brown-Zak oscillations 09:50 PABLO JARILLO-HERRERO Magic Angle Graphene: a New Platform for Strongly Correlated Physics 10:25 ALBERTO MORPURGO Electronic phase transitions in graphene multilayers 11:00 Coffee in the Exhibition Hall 11:30 FELIX CASANOVA Spintronics with 2D-material-based heterostructures 12:05 DEJI AKINWANDE Atomristors: The Discovery of Universal Memory Effect in Monolayer TMDs and h-BN 12:40 CINZIA CASIRAGHI Water-based, biocompatible and inkjet printable 2D-inks
13:15–14:30	LUNCH IN THE EXHIBITION HALL
14:30–15:30	FRINGE SESSION II: PARTNERING DIVISION SUCCESS STORIES Chair: Vincenzo Palermo – Chamber Hall <p>This fringe session offers Graphene Flagship Associated Members and Partnering Projects the opportunity to showcase their graphene-related results.</p> 14:30 LUCIAN COVACI Trans2DTMD project: transport and optoelectronic properties of 2D materials 14:50 ANDREY TURCHANIN H ₂ O – Heterostructures of 2D materials and organic semiconductor nanolayers 15:10 RAQUEL LLORENS-CHIRALT Efficient CO ₂ capture and oil/water separation by innovative adsorbents based on modified Graphene structures
15:30–18:00	PARALLEL SESSION I: FUNDAMENTALS Chairs: Angelika Knothe and Bo Hellsing – Chamber Hall 15:30 STEPHAN ROCHE Tailoring Spin Dynamics in Graphene by Proximity Effects induced by TMDC and Topological Insulators 15:45 TALIEH GHIASI Large spin lifetime anisotropy in transition metal dichalcogenide/graphene heterostructures 16:00 MAHABUB A. BHUIYAN Fe-induced magnetism in van der Waals InSe semiconductor crystals 16:15 ANDRES ARNAU Evidence of large spin-orbit coupling effects in quasi-free-standing graphene on Pb/Ir(111) 16:30 Coffee in the Exhibition Hall 17:00 M. PILAR LÓPEZ-SANCHO Charged topological solitons in zigzag graphene nanoribbons 17:15 GIANCARLO SOAVI Broadband electrically tuneable third harmonic generation in graphene 17:30 ALEXEY KUZMENKO Colossal Landau-level absorption in hBN/graphene/hBN heterostructure 17:45 ANDRÉS AYUELA Stable Carbon Monosulfide Nanostructures: Chain Arrays and Monolayers
15:30–18:00	PARALLEL SESSION II: APPLICATIONS Chairs: Vittorio Pellegrini and Marika Schleberger – Rooms 4+5 15:30 IN HYUK SON Popcorn-like graphene growth for high performance lithium rechargeable batteries 15:45 JUAN LUIS GÓMEZ URBANO The role of graphene-based materials in Li-S batteries 16:00 HUBERT BEISCH Globugraphite – new carbon foam for technical application 16:15 PANIZ SOLTANI Synthesis of Novel Carbon Materials for Supercapacitor Applications 16:30 Coffee in the Exhibition Hall 17:00 LAURA CIAMMARUCHI Hydrogen storage in carbon via water splitting 17:15 SEBASTIANO BELLANI 2D crystals for efficient, solution-processed, pH-universal electrocatalysts for hydrogen evolution reaction 17:30 MARK BISSETT Chemically functionalized laminar MoS ₂ membranes for nanofiltration 17:45 KAI-GE ZHOU Tunable graphene-based membranes

15:30–18:00

PARALLEL SESSION III: SYNTHESIS AND GROWTH

Chairs: Claire Berger and Chong Min Koo – Rooms 8+9

- 15:30 HENRI PRÉVOST** Low Pressure CVD growth of multilayer sp² Boron Nitride on metallic substrates and extended characterization
- 15:45 DEBDEEP JENA** Quantum Materials and Devices Built Using 2D Materials
- 16:00 ABHAY SHIVAYOGIMATH** A general approach for the synthesis of two-dimensional compounds by chemical vapour deposition
- 16:15 ALBERT DAVYDOV** CVD growth of n- and p- type MoTe₂ single crystals for phase-change applications
- 16:30** Coffee in the Exhibition Hall
- 17:00 ARAN GARCIA-LEKUE** Multifunctional nanoporous graphene: bottom-up synthesis and electronic characterization
- 17:15 JOAN REDWING** Epitaxial growth of wafer-scale transition metal dichalcogenides by gas source CVD
- 17:30 JACEK BARANOWSKI** Structural and Electronic Properties of Carbon Doped Boron Nitride Epilayers
- 17:45 MASAKI TANEMURA** Exploration of novel catalysts for the low temperature growth of graphene based on *in-situ* TEM

15:30–18:00

GRAPHENE INNOVATION FORUM: STANDARDISATION – Chair: Thomas Reiss – Rooms 6+7

- 15:30 ALBERT REDÓ** A step forward for graphene quality control standardization: ONYX
- 15:50 ANDREW POLLARD** Rapid characterisation of the size of commercially-produced graphene and graphene oxide flakes
- 16:10 SAMANEH ETEMADI** A systematic study of stability of Graphene oxide (GO)
- 16:30** Coffee in the Exhibition Hall
- 17:00 NORBERT FABRICIUS** Graphene Industrialization – The Role of Documentary Standards
- 17:20 ANGELA HIGHT-WALKER** Metrology and Standardization in Emerging Areas: Graphene and 2D Materials
- 17:40 JI-BEOM YOO** Strategy and activities of standardization of graphene and related 2D materials in Korea

14:30–18:00

GRAPHENE FOR HUMAN SPACE EXPLORATION WORKSHOP

Chairs: Carlo Saverio Iorio, Monica Monici, Lucia Delogu, Alberto Bianco – Room 10 B+C

- 14:30 DESIRE PANTALONE** Acute care surgery and trauma surgery in extreme environment
- 14:45 CHIARA ZANARDI** Electrochemical bio-sensors based on 2D materials
- 15:00 MONICA MONICI** The role of mechanical factors in wound healing
- 15:15 LIVIA ELENA CRICA** How do graphene oxide sheets interact with the blood in vivo
- 15:30 MARCO PELIN** Impact of graphene related materials on skin keratinocytes: are they suitable for wound healing applications?
- 15:45 LUCIA MORBIDELLI** Safety and biocompatibility of synthetic biomaterials to be used in tissue repair and regeneration
- 16:00 ESTER VAZQUEZ** Preparation and Applications of Hybrid Graphene Hydrogels
- 16:15 MANUELA MELUCCI** Enhanced adhesion of brain cells on biomimetic graphene-oxide-phospholipids substrates
- 16:30** Coffee in the Exhibition Hall
- 17:00 GABRIELE CECCARELLI** Autologous micro-grafts for tissue engineering applications
- 17:15 LUCIA GEMMA DELOGU** Graphene immune modulation
- 17:30 YARJAN ABDUL SAMAD** Chemiresistive sensing with exfoliated graphite/polymer aerogels
- 17:45 MAURIZIO CASALINO** Vertically illuminated near-infrared graphene/silicon photodetectors

18:00–20:00

WOMEN IN GRAPHENE – Chair: Siân Fogden – Banquet Hall

The Graphene Flagship's Women in Graphene initiative was established to help support women and create a more gender diverse scientific community. A group discussion will follow the presentations in this session.

ANNICK LOISEAU My Path in Science as a Response to a Physics Professor's Statement on Gender Issues in the Seventies

SANNA ARPIAINEN The Gender Effect

ALBA CENTENO Switching Career from Academia to Industry

18:00–19:30

POSTER SESSION 2

WEDNESDAY 12 SEPTEMBER

08:00–18:00	REGISTRATION & HELPDESK
11:00–18:00	EXHIBITION – Exhibition Hall
09:00–13:15	PLENARY SESSION – Chairs: Irene Palacio and Nikolaus Nestle – Chamber Hall
	09:00 GEORG DÜSBERG Growth of TMDs for applications in future electronics 09:50 LUIGI COLOMBO A perspective on single crystal growth of 2D materials 10:25 CLAIRE BERGER Epitaxial graphene: from semiconducting to exceptional ballistic conductors 11:00 Coffee in the Exhibition 11:30 PETER BØGGILD Manufacture and metrology challenges for 2D material 12:05 VINCENZO PALERMO Selective gas permeation in graphene oxide-polymer self-assembled multilayers 12:40 BRUNETTO MARTORANA Graphene: a frontier for a new class of Multifunctional Lightweight Structures in Automotive Sector
13:15–14:30	LUNCH IN THE EXHIBITION HALL
14:30–15:30	FRINGE SESSION III: PUBLISHING GRAPHENE RESEARCH – Chamber Hall
	Publishing one's work is an important part of any researchers career. Take the opportunity to meet editors from scientific journals and learn more about their work in this session. Moderator: REBECCA WATERS Graphene Flagship Communications Officer Panellists: ALEX WOTHERSPOON Publisher for Nanotechnology, 2D Materials COSTAS GALIOTIS Editor-in-Chief for Graphene Technology ELENA BELSOLE Editor-in-Chief for Communications Physics OLGA BUBNOVA Associate Editor for Nature Nanotechnology
15:30–18:00	PARALLEL SESSION I: FUNDAMENTALS – Chairs: Vladimir Falko and Costas Galiotis – Chamber Hall
	15:30 ANNICK LOISEAU Studying the dielectric function of free-standing 2D materials with angular resolved electron energy loss spectroscopy 15:45 EVAN REED A guided safari through the properties of over 1000 layered materials revealed by data mining techniques 16:00 ION ERREA CDW temperature in bulk and monolayer transition metal dichalcogenides from first-principles 16:15 NIELS HESP Super-planckian electron cooling in a Van der Waals stack 16:30 Coffee in the Exhibition 17:00 SAMUEL BREM Exciton Relaxation Cascade in Two-dimensional Transition-metal dichalcogenides 17:15 AMBER McCREARY Intricate Resonant Raman Response in Anisotropic Rhenium Diselenide (ReS ₂) 17:30 GWAN-HYOUNG LEE Characterizing chemically grown MoS ₂ grain boundaries by atomic force microscopy 17:45 JAKE GREENER Coherent acoustic phonons in van der Waals InSe nanolayers and InSe/hBN heterostructures
15:30–18:00	PARALLEL SESSION II: APPLICATIONS Chair: Marco Romagnoli and Siva Bohm – Rooms 4+5
	15:30 JEANIE LAU Spin and Charge Transport in Few-Layer Graphene and Phosphorene Devices 15:45 MUHAMMAD ASAD Graphene field-effect transistors for high frequency applications 16:00 KURT GASKILL Remote epitaxy: a path to tomorrow's electronics 16:15 STEVEN KOESTER 2D materials for a new generation of multi-functional devices 16:30 Coffee in the Exhibition 17:00 LUCIA LOMBARDI Loop heat pipes for space applications with graphene coated wicks 17:15 TIAN CAREY Spray coating thin films on three-dimensional surfaces for a semi-transparent capacitive touch device 17:30 CRISTINA VALLES Sprayable highly conductive graphene/polyelectrolyte layer-by-layer coatings 17:45 MARCO GOISIS Development of new graphene-modified photocatalysts for cementitious surfaces for environmental remediation

15:30–18:00

PARALLEL SESSION III: SYNTHESIS AND GROWTH

Chairs: Sara Dale and Luigi Colombo – Rooms 8+9

- 15:30 GABRIELA COPETTI** Incorporation of chlorine and fluorine dopants on MoS₂
- 15:45 MAXIM RYBIN** Modification of the optical and electrical properties of CVD graphene
- 16:00 ANDREAS JOHANSSON** Dressing graphene with a pattern of epoxy and hydroxyl groups
- 16:15 CIAN BARTLAM** On the rational design of aqueous graphene dispersants
- 16:30** Coffee in the Exhibition
- 17:00 MICHAL OTYEPKA** Synthesis and Properties of Covalently Functionalized Graphenes
- 17:15 FUMIN HUANG** Layer-by-layer laser thinning of graphene oxide few-layers
- 17:30 ALBERTO FINA** Molecular Junctions between Graphene Nanoplatelets to Enhance Heat Transfer in Nanomaterials
- 17:45 YASUNORI TATENO** Chemical State Analysis on the Interface between Graphene and Al₂O₃ using Synchrotron Radiation

15:30–18:00

GRAPHENE INNOVATION FORUM: COMMERCIALISATION – Chair: Sophie Charpentier – Rooms 6+7

- 15:30 ALBA CENTENO** Graphene Wafer Scale Integration
- 15:50 FRANCESCO BONACCORSO** Graphene-based Materials: The route Towards Commercialization
- 16:10 RICHARD-MARC LACASSE** Graphene Start-ups: Making Inroads on the Canadian Stock Markets
- 16:30** Coffee in the Exhibition
- 17:00 IÑIGO CHAROLA** High-quality CVD Graphene Field-Effect Transistors
- 17:20 IÑIGO MARTIN FERNANDEZ** Integration of CVD graphene for wafer scale fabrication of devices
- 17:40 KEN VERGUTS** Ion intercalation is the main mechanism to delaminate CVD graphene from platinum substrates

18:00–19:30

POSTER SESSION 3**GRAPHENE INNOVATION FORUM****ROADMAP****15:30–18:00 MONDAY, 10 SEPTEMBER**

The Graphene Innovation Forum begins with a session dedicated entirely to roadmapping graphene and other 2D materials towards future applications and will focus firmly on the needs and perspectives of industry. Graphene and other 2D material technologies have promising properties and the potential to lead to advancements in different applications.

STANDARDISATION**15:30–18:00 TUESDAY, 11 SEPTEMBER**

The importance of standardisation for any material that is to be commercially successful cannot be overstated and there are many different issues surrounding standardisation of graphene and other 2D materials. Several of these issues will be explored in this session.

COMMERCIALISATION**15:30–18:00 WEDNESDAY, 12 SEPTEMBER**

Commercialisation is at the heart of the Graphene Innovation Forum and this session will explore how to accelerate graphene and related 2D materials through to commercialisation.



THURSDAY 13 SEPTEMBER

08:00–18:00	REGISTRATION & HELPDESK
11:00–18:00	EXHIBITION – Exhibition Hall
09:00–13:15	PLENARY SESSION – Chairs: Laura Ciammaruchi and Marco Goisis – Chamber Hall 09:00 CLARE GREY Applications of Graphene and 2D Carbons in Energy Storage 09:50 VITTORIO PELLEGRINI Graphene-based electrodes for high-power batteries 10:25 MAURICIO TERRONES A review of Defects in Metal Dichalcogenides: Doping, Alloys, Interfaces, Vacancies and Their Effects in Catalysis & Optical Emission 11:00 Coffee in the Exhibition 11:30 MARIKA SCHLEBERGER Nanoporous 2D materials: From Membranes to Catalysis 12:05 SLAVEN GARAJ Graphene-based membranes 12:40 SIVA BOHM Industrial applications of graphene tuned coatings
13:15–14:30	LUNCH IN THE EXHIBITION HALL
14:30–15:30	FRINGE SESSION IV: SUSTAINABLE RESEARCH & INNOVATION Chair: Vincenzo Palermo – Chamber Hall <p>Given the potential impacts of the Graphene Flagship, concepts, methods and tools are required to ensure that the research conducted and the innovations created in this context address society's needs, do not clash with fundamental societal values, and anticipate as far as possible unintended effects.</p> 14:30 RALF LINDNER Towards Responsible Research and Innovation in the Graphene Flagship: Concepts and Practical Approaches 15:00 BENGT FADEEL Safety assessment of graphene-based materials: lessons from Nano safety research
15:30–18:00	PARALLEL SESSION I: FUNDAMENTALS – Chair: Xiaodong Xu and Dmitri Basov – Chamber Hall 15:30 MIKA PETERSSON Optical forging of graphene into three-dimensional shapes 15:45 CARINO FERRANTE Raman spectroscopy of graphene under ultrafast laser excitation 16:00 KEN LIU Ultra-fast Photon emission and pulse propagation in graphene 16:15 MORTEN GJERDING Layered van der Waals crystals and heterostructures with hyperbolic light dispersion 16:30 Coffee in the Exhibition 17:00 MARTA AUTORE Boron nitride nanoresonators for enhanced molecular vibrational spectroscopy and strong coupling 17:15 ANTONELLO SINDONA Interband plasmon of silicene grown on silver 17:30 DAVID ALCARAZ Confinement of plasmons down to one atom with Graphene/hBN/metal Heterostructures 17:45 IRATI ALONSO A near deterministic plasmonic quantum Zeno gate using graphene nanoribbons
15:30–18:00	PARALLEL SESSION II: APPLICATIONS Chairs: Teófilo Rojo and Maurizio Prato – Rooms 4+5 15:30 SANJAY B. THORAT Graphene-polymer composites: the effect of flakes aspect ratios on the composite properties 15:45 GRISELDA GALLAND Polyolefin/r-GO/CNT-Fe nanocomposites with magnetic and semiconductor properties 16:00 ANASTASIOS MANIKAS Out-of-plane phenomena and fracture of graphene/polymer systems 16:15 RANI ROHINI Excellent electromagnetic wave absorber for Ku-band frequency derived from functional GO/epoxy/carbon fiber composites 16:30 Coffee in the Exhibition 17:00 LUCIA DELOGU Transcriptomic and single cell interaction properties of graphene in human primary immune cells 17:15 INÊS GONÇALVES Coatings of graphene nanoplatelets for antimicrobial silicone catheters 17:30 LAURA SAENZ DEL BURGO Hybrid alginate-graphene oxide microcapsules for the development of cell-based therapies 17:45 MARÍA CONCEPCIÓN SERRANO Tissue response of the injured rat spinal cord to the implantation of reduced graphene oxide scaffolds and microfibers

15:30–18:00

PARALLEL SESSION III: SYNTHESIS AND GROWTH

Chairs: Peter Bøggild and Sanna Arpiainen – Rooms 8+9

- 15:30 IRENE PALACIO** NaCl films as capping layers for graphene
- 15:45 IAN KINLOCH** Electrochemical Exfoliation of 2D materials for composite and energy applications
- 16:00 YU-WEI ZHANG** Complete selenization of MoS₂ to form wafer-scale and layer number controllable MoSe₂ films
- 16:15 HAPPINESS IJIJE** Production of graphene related materials in molten chlorides
- 16:30** Coffee in the Exhibition
- 17:00 NIKOLAUS NESTLE** Scaling up material innovations enabled by top-down GRM: a need for value chain bundles reflecting coupled production
- 17:15 ESTER VAZQUEZ** Sweet Green Graphene: A Mechanochemical Synthesis
- 17:30 BLERINA GJOKA** Towards Highly Modified Graphene Oxide and Functional Derivatives for Industrial Applications

15:30–18:00

US-EU WORKSHOP ON 2D MATERIALS – Chairs: Alan Seabaugh and Vladimir Falko – Rooms 6+7

- 15:30 ANDREA FERRARI** Light scattering and emission from layered materials
- 15:45 ALAN SEABAUGH** Top-gated few-layer WSe₂-on-sapphire field-effect transistors grown by chemical vapor deposition
- 16:00 MARCO ROMAGNOLI** Graphene use in photonics for telecommunications
- 16:15 SUSAN FULLERTON** Using ions to control transport in two-dimensional materials
- 16:30** Coffee in the Exhibition
- 17:00 THOMAS MUELLER** Second harmonic generation in strained 2D semiconductors
- 17:15 ROMAN GORBACHEV** Fabrication of the next generation of devices
- 17:30 GIULIO CERULLO** Electron cooling and carrier dynamics
- 17:45 JURGEN SMET** Ultrafast diffusion and superdense ordering of lithium in bilayer graphene

18:00–19:30

POSTER SESSION 4

20:00–23:00

CONFERENCE DINNER

WELCOME RECEPTION: KURSAAL FOYER



20:00–22:00 MONDAY, 10 SEPTEMBER

The Graphene Week 2018 welcome reception will be open to all delegates. The reception will be held in the Kursaal Foyer, the most singular and emblematic spot of the conference centre, designed by the prestigious architect Rafael Moneo. The Kursaal Foyer stands out for its luminosity and its two large windows facing out towards the Cantabrian sea. A perfect spot to watch the sunset in September.

CONFERENCE DINNER: SAN TELMO MUSEUM



20:30–23:00 THURSDAY, 13 SEPTEMBER

The conference dinner will be held in the San Telmo Museum, located inside an old Dominican convent from the mid-16th century, situated in the Old Town of San Sebastian. The museum itself is the Basque Country's oldest museum. Opened in 1900 as a Historical, Artistic and Archaeological Museum, it was relocated to the Dominican convent in 1932. Today, it is reintroducing itself as a Museum of Basque Society and Citizenship.

The delegates will have the opportunity to visit part of the museum's permanent collection and to taste some of the region's world-recognised cuisine in a peaceful and historical setting.

FRIDAY 14 SEPTEMBER

08:30–14:30

HELPDESK

09:00–13:15

PLENARY SESSION – Chairs: Inês Goncalves and Ester Vazquez – Chamber Hall

09:00 **ARBEN MERKOÇI** Graphene-based biosensors

09:50 **HOSSAM HAICK** Stretchable and Multi-Functional Transistor with Intrinsic Self-Healing Properties for Biomedical Applications

10:25 **ALBERTO BIANCO** Functional graphene materials for therapy and imaging

11:00 Coffee

11:30 **JOSÉ M NAVAS** Interaction of graphene related materials and cellular structures: Alterations implications, and applications

12:05 **BENGT FADEEL** Safety assessment of graphene oxide: focus on the immune system

12:40 **ULLA VOGEL** Inhalation toxicity of carbon-based nanomaterials

10:00–16:00

US-EU WORKSHOP ON 2D MATERIALS – Room 10A

10:00 **JOSHUA ROBINSON** Discovering, Creating, and Exploring Novel Atomically-Thin Materials and Heterostructures

10:15 **MARCO POLINI** Linear and non-linear hydrodynamic flow in graphene

10:30 **ROGER LAKE** One dimensional van der Waals materials

10:45 **ALEXANDER TARTAKOVSKI** Optics of TMDC heterostructures

11:00 Coffee

11:30 **ALESSANDRO TREDECUCCI** On-chip strain engineering platform for two-dimensional materials

11:45 **ERIC VOGEL** Two-dimensional Materials for Vertical Heterostructures

12:00 **ROBERT WALLACE** Contact interfaces and transition metal dielectrics

12:15 **PEIDE YE** 1D van der Waals Nanomaterials: Selenium and Tellurium

12:30 **JAMES HWANG** Wafer-scale fabrication of MoS₂ and PtSe₂ MOSFETs

12:45 **ERIC POP** Electrical, thermal and unconventional applications of 2D materials

13:15 Lunch and Closing Ceremony

14:00 **GROUP DISCUSSION** (2 hours) **Moderators:** Eric Pop, Joan Redwing, Angela Hight-Walker

13:15–13:30

CLOSING CEREMONY

13:15–14:30

LUNCH

US-EU WORKSHOP ON 2D MATERIALS

15:30–18:00 THURSDAY, 13 SEPTEMBER

10:00–16:00 FRIDAY, 14 SEPTEMBER

Co-organized by the United States' National Science Foundation (NSF) and Europe's Graphene Flagship, the 4th US-EU Workshop on 2D Materials provides a venue for discussing the common challenges and opportunities in this rapidly developing research area. The aim of the workshop is to learn about each other's work and to further the strong tradition of collaboration between the US and the European Union.

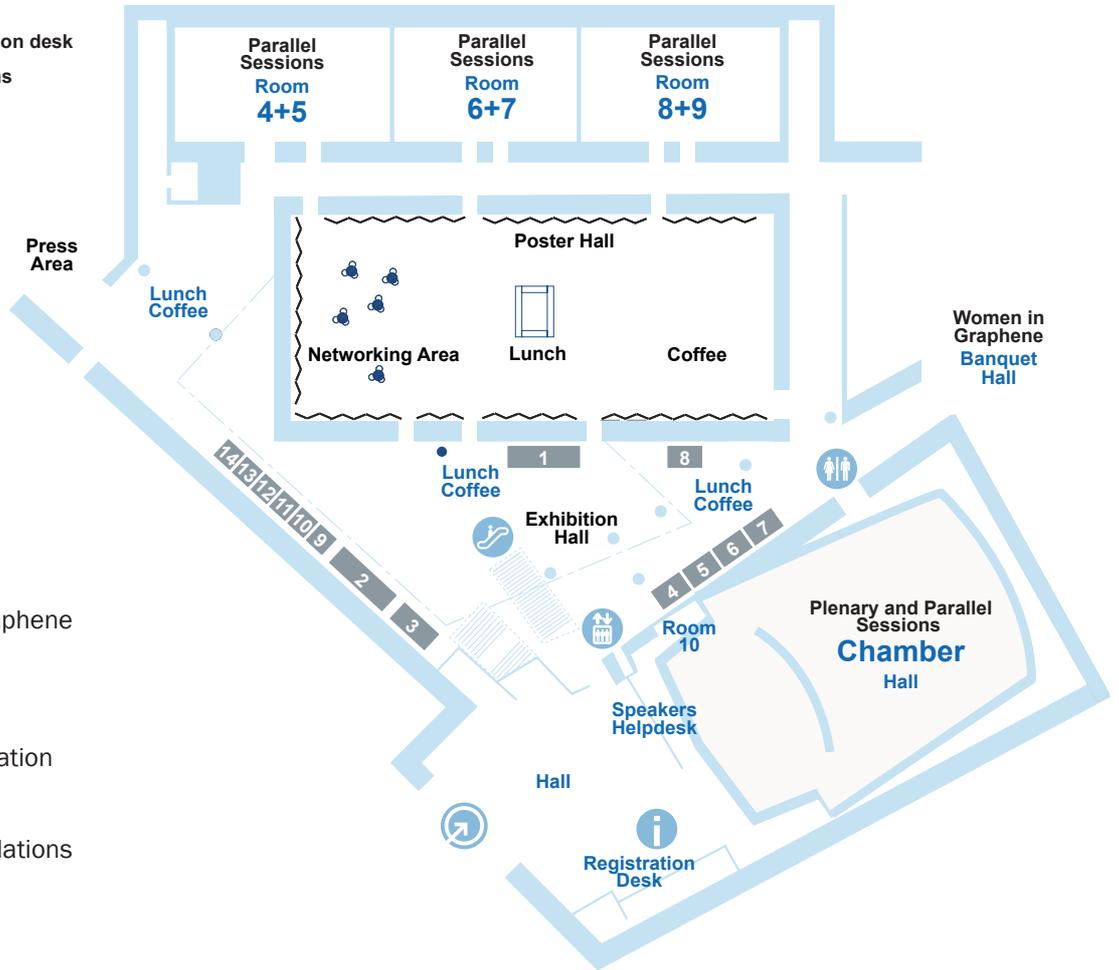


CONFERENCE MAP

-  Registration desk
-  Restrooms
-  Lift
-  Escalator

LIST OF EXHIBITORS

- 1 CIC nanoGUNE
- 2 Graphene Flagship
- 3 Thinky Corporation
- 4 Das-Nano
- 5 SIO Grafen
- 6 IOP Publishing
- 7 BeDimensional - IIT Graphene
- 8 neaspec
- 9 TECNALIA
- 10 CVD Equipment Corporation
- 11 AMO GmbH
- 12 Simune Atomistic Simulations
- 13 Graphmatech
- 14 Merck (Sigma-Aldrich)



EXHIBITORS



SPONSORS



COLLABORATORS





“Graphene Week provides good perspective on what’s going on in the community, especially about more applied research,” Noble Laureate Andre Geim says.

ANDRE GEIM The University of Manchester



Graphene Week is great “for networking especially if you are working in graphene and 2D materials, not only for academics and research centres but also for industry.”

AMAIA ZURUTUZA Graphenea



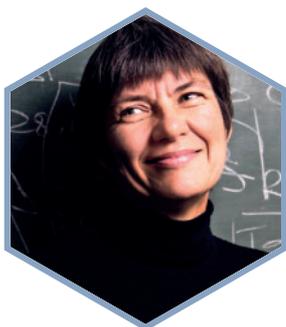
“I look forward to learning from my colleagues about their latest research, as well as meeting and speaking with PhD students and postdocs”, MIT’s Pablo Jarillo-Herrero says of Graphene Week. “Of course, San Sebastian’s famous cuisine will be a highlight in the evenings!”

PABLO JARILLO-HERRERO Massachusetts Institute of Technology



“Graphene Week is the only graphene conference that has a large focus on fundamental science in addition to the applications, a balance other conferences don’t have, making it unique in the landscape of graphene events,” says Nobel Laureate Konstantin Novoselov.

KONSTANTIN NOVOSELOV The University of Manchester



“As a toxicologist in nanosafety, I really look forward to being able to disseminate knowledge on safe use of nanomaterials to a lot of scientists who work with nanomaterials,” says Ulla Birgitte Vogel, who will be speaking at Graphene Week. “Graphene Week is an excellent forum because it will allow me to reach a large forum of innovators.”

ULLA BIRGITTE VOGEL National Research Centre for the Working Environment, Denmark



Graphene Week “is, of course, one of the main international events focused on graphene and related materials,” says Deji Akinwande of The University of Texas at Austin. “It is special because many of the experts attend this event sharing the latest breakthroughs before they are widely published.”

DEJI AKINWANDE The University of Texas at Austin

MEET THE CHAIR

By Rebecca Waters



While we may know him as the Graphene Week 2018 Conference Chair, Jose Maria Pitarke is the founding director of the Basque Nanoscience Research Center nanoGUNE, in San Sebastian, Spain, and a full professor of physics researching fundamental aspects of electronic excitations in two-dimensional materials at

the University of the Basque Country. Between meetings to fine-tune this year's fantastic conference line-up, we took the opportunity to get to know him better.

RW: Tell us about your research.

JMP: Recently, I have been looking at collective excitations (plasmons) in graphene and other two-dimensional materials. We predicted a new class of plasmons (acoustic plasmons) in doped graphene that are expected to exist in addition to the conventional two-dimensional plasmons that occur in this material. We have also been looking at plasmon modes in bilayer graphene and graphene nanoribbons, and now we are looking at collective excitations in other two-dimensional materials, including the development of fundamentals that allow for an accurate theoretical description of the optical response of these materials.

RW: What are your professional aspirations?

JMP: In addition to my own research, my professional aspirations are focused on the consolidation of nanoGUNE, a research centre that was launched only a few years ago and which we would like to see recognized not only as a research centre that is carrying out top-class, state-of-the-art research but also as a research centre that contributes to the economic development of a knowledge-based society in the Basque Country and worldwide.

RW: How has nanoGUNE's participation in the Graphene Flagship impacted your work?

JMP: Our Graphene-Flagship participation has been very much focused on the experimental work that is being carried out by Rainer Hillenbrand and his group on plasmonics and phononics in two-dimensional materials. This work is having a large impact within the graphene and nanooptics communities and a patent has already been submitted, to a great extent thanks to our participation in the Graphene Flagship.

RW: In addition to your own research and the research of others at nanoGUNE, you have also led the creation of a graphene producing company. Could you tell us about this experience?

JMP: In 2010, only one year after nanoGUNE's inauguration, we founded our first start-up company, Graphenea, as a joint venture with private investors. Our mission was to produce and commercialise high-quality graphene wafers and develop graphene-based technologies. Graphenea is now a world-leading graphene producer and is also a member of the Graphene Flagship.

RW: What advice would you give to early career researchers who would like to follow in your footsteps?

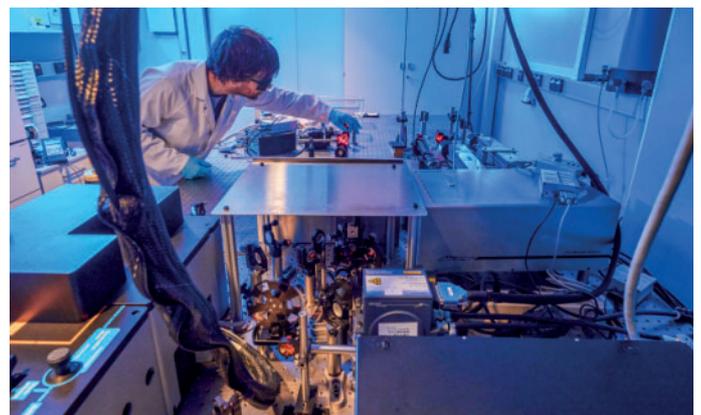
JMP: Here I would like to quote Noble Laureate Heini Rohrer, who was a good friend and a member of nanoGUNE's advisory board. His answer to this question was, "You choose what you like; but once you choose you stick with it and do your best." To this I would add, "move around and be close to the best researchers in the field."

RW: Apart from research, what do you do for fun?

JMP: I enjoy outdoor activities like hiking and cycling, but I also, of course, like reading a good book, listening to a good piece of music and/or watching a classical movie.

RW: Any recommendations on what *not* to miss in San Sebastian and the surrounding area?

JMP: In San Sebastian, attendees should not miss going to the old town for some 'pintxos' in the bars and for a walk from the Kursaal to Txillida's "Comb of the Winds" sculpture at the foot of Mount Igeldo. In the surrounding area, they should go to some of the little picturesque villages in the French Basque Country, only a few kilometres from San Sebastian, or to Getaria for a good 'txakoli'.



BIODEGRADABLE GRAPHENE

By Nishad Karim

Degradation of pristine graphene occurs in the human body when interacting with a naturally occurring enzyme found in the lungs, announced Graphene Flagship partners; the French National Centre for Scientific Research (CNRS), University of Strasbourg, Karolinska Institute and University of Castilla-La Mancha (UCLM).

Graphene-based products are being designed to be interfaced with the human body within the Graphene Flagship, including flexible biomedical electronic devices. If graphene is to be used for such biomedical applications, it should be biodegradable and thus be expelled from the body.

To test how graphene behaves within the body, Alberto Bianco, and his team at Graphene Flagship partner CNRS, conducted several tests looking at if and how graphene was broken down with the addition of a common human enzyme. The enzyme in question, myeloperoxidase (MPO), is a peroxide enzyme released by neutrophils, cells that are responsible for the elimination of any foreign bodies or bacteria that enter the body, found in the lungs. If a foreign body or bacteria is detected inside of the body, neutrophils surround it and secrete MPO, thereby destroying the threat. Previous work by Graphene Flagship partners found MPO to successfully biodegrade graphene oxide [Small, 2015, 11, 39 85-3994 and Nanoscale 2018, 10, 1180-1188]. However the structure of non-functionalized graphene was thought to be more degradation resistant. To test this, Bianco and his team looked at the effects of MPO, *ex vivo*, on two graphene forms: single- and few-layer.

Bianco explains, “We used two forms of graphene, single- and few-layer, prepared by two different methods in water. They were then taken and put in contact with myeloperoxidase in the presence of hydrogen peroxide. This peroxidase was able to degrade and oxidise them. This was not really expected because we thought that non functionalized graphene was more resistant than graphene oxide.”

Rajendra Kurapati, first author on the study, from Graphene Flagship partner CNRS, said, “The results emphasize that highly dispersible graphene could be degraded in the body by the action of neutrophils. This would open the new avenue for developing graphene-based materials.”

With successful *ex-vivo* testing, *in-vivo* testing is the next stage. Bengt Fadeel, professor at Graphene Flagship partner Karolinska Institute, “Understanding whether graphene is

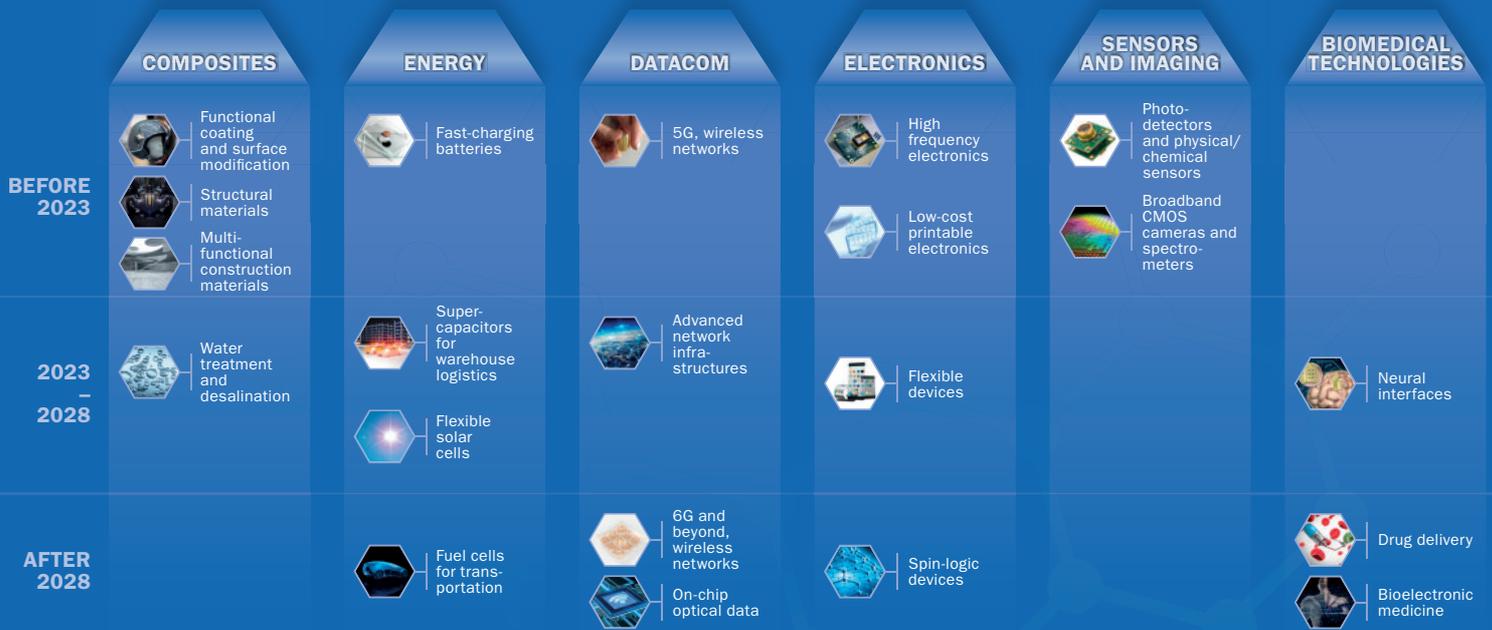


biodegradable or not is important for biomedical and other applications of this material. The fact that cells of the immune system are capable of handling graphene is very promising.”

Maurizio Prato, leader of the work package dealing with health and environment impact studies, based at Graphene Flagship Partner University of Trieste, said, “The enzymatic degradation of graphene is a very important topic, because in principle, graphene dispersed in the atmosphere could produce some harm. Instead, if there are microorganisms able to degrade graphene and related materials, the persistence of these materials in our environment will be strongly decreased. These types of studies are needed. What is also needed is to investigate the nature of degradation products. Once graphene is digested by enzymes, it could produce harmful derivatives. We need to know the structure of these derivatives and study their impact on health and environment.”

Andrea C. Ferrari, science and technology officer of the Graphene Flagship, and chair of its management panel added, “The report of a successful avenue for graphene biodegradation is a very important step forward to ensure the safe use of this material in applications. The Graphene Flagship has put the investigation of the health and environment effects of graphene at the centre of its programme since the start. These results strengthen our innovation and technology roadmap.”

This work has been published in *Angewandte Chemie, International Edition* 2018, DOI: 10.1002/anie.201806906, titled: ‘Degradation of Single-Layer and Few-Layer Graphene by Neutrophil Myeloperoxidase,’ by R. Kurapati, S. P. Mukherjee, C. Martín, G. Bepete, E. Vázquez, A. Pénicaud, B. Fadeel and A. Bianco.



MAPPING GRAPHENE'S INDUSTRY POTENTIAL

By Rebecca Waters

The Graphene Flagship's Technology and Innovation Roadmap (TIR) demonstrates the various paths that graphene can take to transition from the lab to use in industrial applications. The roadmap aggregates a common view on graphene and related materials (GRM) and provides guidance for graphene research towards market demands. It establishes a timeline for when one can expect graphene to be applied to different application areas.

In every focus investigation, the insufficient maturity of the graphene industry was identified as a major challenge to the commercialisation of graphene-based products. Beyond the expansion of production capacity and simultaneous price reductions, key factors for the commercialisation of GRMs include regulatory hurdles, a lack of standardisation and technical demands to graphene properties often only defined in the specific application context.

Through a series of workshops, the Graphene Flagship's industrialisation team worked to identify specific markets in which graphene could fill a niche or was uniquely suited to

solve an industry problem. The latest version of the TIR specifically explored four promising areas for graphene commercialization: supercapacitors, anti-corrosion, Li-ion batteries and neural interfaces.

"Each individual focus investigation explores specific potential future value chains down to exemplary end products such as forklifts, off-shore wind power or hearing aids," says Henning Döscher of the Graphene Flagship industrialisation group. "The idea is both promoting information exchange across the specific industrial innovation interfaces and deducing exemplary, in-depth information on drivers and obstacles for GRM commercialization."

"We learn that some aspects may be unique for a very specific niche, others may be at least similar among several application areas, and some issues occur over and over again. Expanding to new focus investigation topics, we hope to both explore further exciting highlight application areas of graphene and, in the sum of the distinct examples, eventually, to obtain a more in-depth understanding of the diverse graphene

applications and to foster their impact on European industries. Hence, we intensified our efforts to involve stakeholder inputs from both industry and the Graphene Flagship to identify and select meaningful topics that promise high specific impact and complement our perspective on the entire field," he adds.

The industrialisation group's work over the first five years of the Graphene Flagship identified unmet industrial needs in several sectors, such as energy, automotive and logistics, where GRM could offer solutions in the medium or long run.

"For instance, the logistics industry does not only strive for advanced forklifts (with better suited energy supply systems), but also for novel warehouse systems based on automated guided vehicles (AGV) for which the energy supply demands may shift dramatically," notes Thomas Reiss, deputy leader for the Graphene Flagship industrialisation group. "However, most of the industrial experts involved in any of our workshops were not aware of the needs and offers of the other stakeholder groups positioned down or up the value chain compared to their own. Hence, there is an urgent need for introducing and elaborating this value chain perspective for

different application scenarios. That is exactly what we will intensify in the forthcoming roadmapping work."

In elaborating the current roadmap, the team discovered significant scepticism towards industrial graphene utilization. The common denominator in industry anecdotes, either from active experience or passive observation, was a lack of quality standards. Therefore, further focus on the Graphene Flagship's standardization efforts will be key to graphene's success in the marketplace.

"The lack of application-oriented and traceable material quality standards appears to be the single most important barrier for graphene industrialization across all application fields," Döscher says.

"The interaction between Graphene Flagship partners and the TIR group has worked very well in the past, and we strongly encourage keeping it up and extending it in the future," Reiss says. Project members can access the group's results on the Flagship's intranet and are encouraged to continue to support and participate in future TIR activities.

GRAPHENE FLAGSHIP VALIDATION SERVICE



To support the successful exploitation of graphene and other 2D materials, the Graphene Flagship has launched a new validation service. The service is provided by authorised national measurement institutes and facilities renowned for their excellence, independence, integrity and impartiality.

The service will initially provide structural, mechanical, optical, thermal, electrical, magnetic, chemical and lifecycle measurements of graphene-enhanced bulk composite materials. During the lifetime of Core 2, new services will be added.

The service is open to everyone and free of charge to Graphene Flagship consortium partners (while budgets permit). The service is 'open for business' at the end of September 2018.

Place your order now!

Learn more:

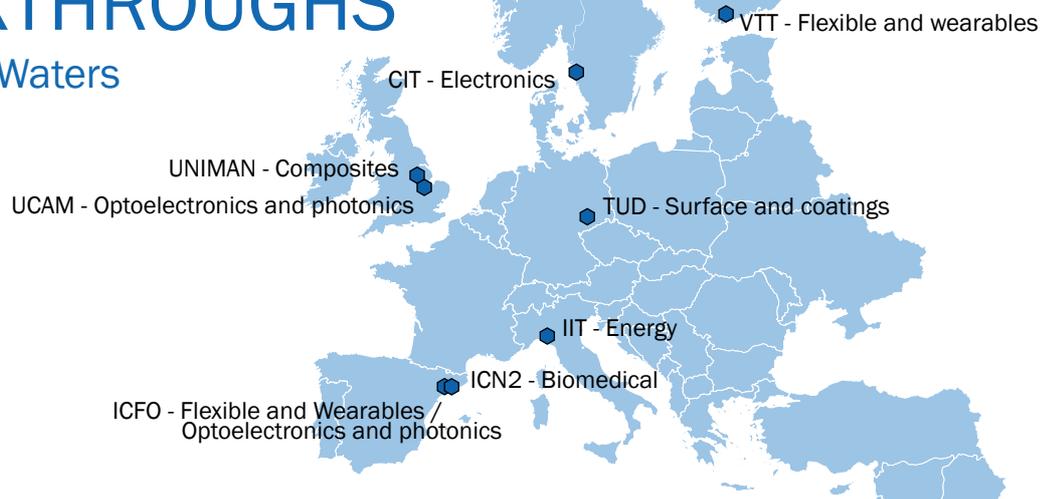


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FOSTERING TECHNOLOGICAL BREAKTHROUGHS

By Rebecca Waters



The Graphene Flagship has been tasked with taking technologies based on graphene and related materials from the laboratory to commercial applications by 2023. This mission has put the project's focus on its innovation efforts.

“During the first phase of the project we continued to witness the potential of graphene-based technologies to create market disruptions and transformational innovations,” says Graphene Flagship Head of Innovation Kari Hjelt. “In the next phase we continue to move from materials research towards component development and system-level integration. Our focus is in combining technology push and market pull by working with industry stakeholders to increase technology readiness levels.”

Beginning in April 2018, the Graphene Flagship's innovation team has hired business developers to help bridge the gap between the laboratory and the marketplace. Each business developer serves a specific graphene application area and help to identify industry needs and how graphene can address them.

“The business developers are the key players in creating the network connecting our research efforts to industry. Their task ranges from scouting the recipients for our technologies to being messengers from industry when it comes to industry trends, needs and roadmaps. They arrange workshops and help teams to create business models,” Hjelt says.

To further the transition towards technology ready applications, the Graphene Flagship will now fund a number of spearhead projects, each with well-defined, application-oriented objectives that are motivated by market opportunities.

These spearheads will focus on a wide range of application areas, from solutions for 5G data transmission to solar energy and wearable electronics, but all have the common goal of developing new or improved products with integrated graphene or related materials (GRM).

“All of the spearhead projects have strong company involvement and are committed to producing industrial prototypes within two years in order to spur interest among companies that are currently not involved with the Graphene Flagship,” says Graphene Flagship Director Jari Kinaret.

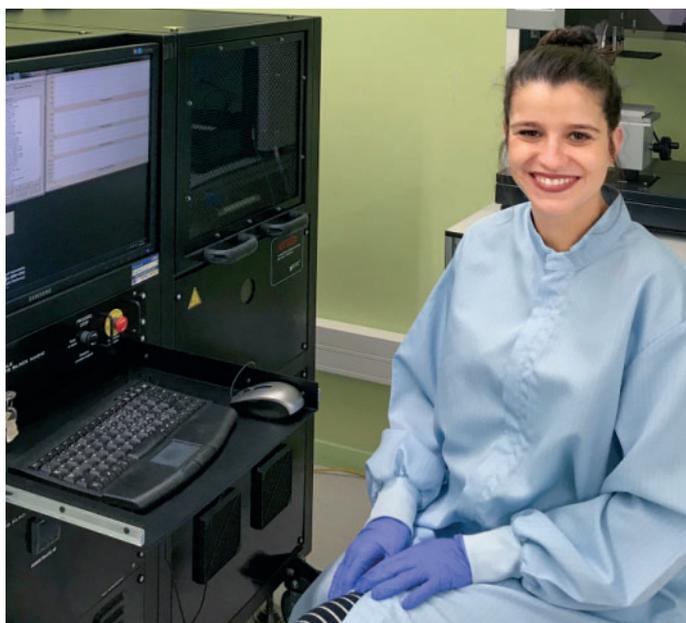
“The spearhead projects target GRM commercialization in very specific highlight application areas,” says Thomas Reiss, deputy leader of the Graphene Flagship's industrialisation team.

“Success in any of these projects may drive the industrialisation of the whole field, and thus also enhance the impact of the Graphene Flagship in its entirety.”

“The collaboration with the battery spearhead team in the first phase of the project was a great success, with high mutual benefits,” agrees Henning Döscher, also on the industrialisation team. “Our future plans will certainly try to leverage that. Our initial Core 2 focus, investigations of perovskite/Si tandem photovoltaics and optoelectronic data communication, are carefully aligned to create highest impact in collaboration with the respective spearhead projects. Some of the other planned topics (such as sensors) should enable further collaboration potential.”

GRAPHENE SPOTLIGHT: MIRIAM MARCHENA

By Nishad Karim



Vital Statistics

Name: Miriam Marchena

Age: 30

Institute: Institute of Photonics Sciences (ICFO)

Here Comes the Science

Field: Photonics

Background: Chemical Engineer

Research: Scalable techniques for graphene on glass: growth, transfer and doping control

Miriam Marchena is a new graduate receiving her doctorate from the Institute of Photonic Sciences (ICFO), this summer, in Photonics. She has just started her first postdoc there.

Research Explained

The technique for implementing graphene at a large scale is Chemical Vapour Deposition (CVD), where graphene is typically grown on copper. However, for this application, copper needs to be removed and graphene located onto the target. This transfer procedure is very challenging, as after that the properties of graphene can be altered, reducing its capabilities. During my thesis, my research focused on the development of a technique where graphene could be directly grown on a glass substrate using a metallic intermediate layer, which would be removed during the growth process, thus avoiding the intermediate transfer step. Depending on the

area and morphology of this metal, we were able to grow large (and patterned) areas of graphene on glass, but also graphene assembled into three-dimensional shapes, widening the applications of graphene.

During an internship at Corning Incorporated (United States), I had the opportunity to develop a fast dry-transfer technique to transfer graphene from the copper foil to a desired target substrate using current industrial equipment.

Applications

Although graphene has many promising and relevant applications, we were mainly focused on graphene as a transparent electrode, as it is a material that combines lightness, high transmittance, conductivity and flexibility. The last property is what makes it ideal for wearables, making it highly promising for future technology demands.

The graphene structures developed during the thesis have not been tested yet. Their high surface area would make them suitable for alternative applications in catalysis and as membranes for water filtration.

Why academia?

For me at the beginning it was not clear, but then I was very enthusiastic about research, especially how to innovate and create things; I liked the idea of developing processes to make something that could improve real applications. So I guess what I liked most was the innovative side of science; how to create new alternatives for doing something and how to design new ways to solve a problem and bring something new to society that could be useful.

What are your plans for the future: academia, industry or other?

So right now, I am in research, but I am considering making the change to industry later. My ideal position would be one where I can carry on doing research for applications and to develop something that could be used in society. Something very applied.

What is your favourite property/fact about graphene?

Graphene is an atomically thin material meaning you can hardly see it; yet it provides such a wide variety of applications.

PHONE OF THE FUTURE

A GRAPHENE ENHANCED PHONE COULD INTEGRATE SEVERAL TECHNOLOGIES DEVELOPED FROM CURRENT GRAPHENE FLAGSHIP RESEARCH

By Fernando Gomollón-Bel

ANTENNA & COMMUNICATIONS

Graphene can be used to enhance optical data communication to unprecedented rates, while reducing energy consumption and transmission errors. The Graphene Flagship targets data links well above 400 gigabit per second by 2020. Graphene could also be the base of flexible, near field communication (NFC) antennas, allowing for the creation of new technologies like electronic banknotes or smart wallets.

PROCESSOR & ELECTRONICS

The electronic properties of graphene make it ideal for creating faster, more reliable components for our phones. Graphene is strong and highly conductive but also really thin – just one atom thick. This could lead to tinier, yet faster microprocessors for smart objects and the Internet of Things. GRMs are flexible, allowing devices to be integrated in textiles or even 'stickers' on our skin.

Source:



SCREEN

Screens using graphene could have force sensors, bringing a new dimension to touchscreen technologies. Moreover, thanks to graphene's high flexibility, we could integrate all these new properties in flexible screens, which could be useful in wearable technology.

SENSORS

Graphene sensors could be useful for many applications: communicating with wellness sensors all over our body monitoring dangerous infections, oxygen and sugar levels, correcting our posture or even helping us track the progress of neural diseases. Sensors could also analyse our environment.

HEADPHONES/SPEAKERS

GRMs could make headphones and speakers more energy efficient and tinier, while producing a better sound. When membranes are light, they are usually too flexible and produce unwanted vibrations and noises. Graphene is flexible, yet strong, so the distortions are reduced, and one can enjoy their favourite music with unprecedented clarity!

BATTERY

Graphene could be used to improve the capacity, efficiency and stability of batteries. Graphene batteries could have higher energy storage and better performance over a lifetime of use and re-charging. Graphene and related materials (GRMs) can also be used to better the properties of other energy storage solutions like supercaps.

CASE

Graphene is a very strong material. Mixed with resins and plastics, or even just as a coating, graphene can be used to make safer helmets, stronger aeroplane parts and more resistant construction materials. Incorporating graphene and related materials into the casing of the phone of the future could make it much more robust. We may never need to worry about dropping it again!

GRAPHENE

WEEK



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GRAPHENE FLAGSHIP



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