



Miracle material enters the limelight with European help

Graphene has moved out of the laboratory and into the market thanks in no small part to the EU, according to Professor Patrik Johansson.

31 May 2024 - By HORIZON STAFF

First isolated in 2004 by future Nobel Prize Laureates, researchers Andre Geim and Konstantin Novoselov at the University of Manchester, this new material made from a single layer of carbon atoms immediately raised the interest of the scientific world with its exceptional properties.

Strong, light, flexible and able to conduct both heat and electricity, graphene had numerous potential applications, including in advanced electronics, batteries, high-performance composite materials, and innovative medical devices and sensors. The Graphene Flagship project, a 10-year EU-funded initiative launched in 2013, has been at the forefront of driving the development of graphene-based technologies and encouraging collaboration between academia and industry.

Involving over 178 academic and industrial research partners, it was one of four long-term, large-scale collaborative research and innovation efforts organised by the EU as part of its Future and Emerging Technologies (FET) programme designed to support early-stage collaborative research into game-changing new technologies. The other three were the Human Brain Project, the Quantum Technologies Flagship and Battery2030+.

Graphene Flagship's goal was to create new technologies based on graphene and other related 2D materials and to make sure that these new technologies moved from the laboratory to society in the form of new products, companies and employment opportunities.

It has helped to make Europe an international leader in the field of graphene and layered materials, created a strong collaborative community, as well as pioneering standards in safety regulations and production policies.

Professor Patrik Johansson, director of the Graphene Flagship, answers Horizon Magazine's questions about the uniqueness of graphene, how far it has come in the past 10 years and what lies ahead.

What is so special about graphene?

Graphene is both simple and beautiful. It is the world's thinnest material – it is a one-atom-thick layer of carbon, one million times thinner than a human hair. At the same time, it is very strong, stronger than both steel and diamond.

Graphene is also very flexible and a great conductor of electricity and heat. And, of course, graphene is light – it is just a layer of carbon atoms!

All the above combined in a single material is truly unique, and this is why we see such an enormous potential in so many vastly different market sectors.

How far have we come in bringing graphene out of the lab and into society?

Graphene has come a very long way, considering that it was just isolated 20 years ago. Graphene is today produced in commercial quantities and actively used in a range of composite materials for applications ranging from sports equipment to cars and planes, as well as in oil and water pipelines.

Applications in electronics, batteries, water and air purification filters, biomedical and other types of sensors are also in, or very close to, market. The [global graphene market](#) reached an estimated annual revenue of \$380 million (€350 million) in 2022 and is expected to grow to \$1.5 billion (€1.38 billion) by 2027.

In which areas are graphene and other 2D materials making the most contribution to European innovation and competitiveness?

Graphene and other 2D materials promise to revolutionise applications in many of Europe's key industries. Taking just one example, leading Graphene Flagship partners such as Airbus, Lufthansa and Leonardo have demonstrated the possibilities of graphene and 2D materials in aeronautics. Graphene is already being used in composite materials that make planes lighter and stronger.

Our researchers have also developed prototypes of graphene air filters capable of removing impurities more effectively than HEPA filters and electrically conductive composites that can keep aircraft ice-free.

Another perspective is that graphene is poised to revolutionise the semiconductor industry by improving the performance of traditional silicon wafers.

European progress in this field could help reduce Europe's reliance on foreign supplies of scarce and environmentally unfriendly materials – a more secure Europe in the end.

What role can 2D materials play in advancing Europe's goals on sustainability?

2D materials can support sustainability goals both through promoting better use of raw materials, as well as by contributing to the harvesting, conversion and storage of renewable energies. They will help make technology more environment friendly.

Graphene's electrical conductivity makes it a suitable replacement for certain scarce raw materials and – by eliminating copper wiring in electronics and electronic components in cars and planes – it will help make these products easier to recycle.

Graphene Flagship researchers have demonstrated that graphene-enhanced solar panels offer improved efficiency and durability. Graphene can also help produce longer lasting and more efficient batteries for electric cars and other applications. Point-of-use water filters made with graphene are able to filter out even emerging contaminants, which are increasingly present in European water sources.

Not to mention that graphene itself can be made from the carbon in waste products like old car tyres and organic waste matter, making it an ideal product for a green circular economy.

How safe are these new materials?

Health and safety have been a key concern for the Graphene Flagship since its inception, with a specialised work group handling this aspect from the very start.

Due to the different production methods involved and the various forms it can take, graphene is not just one material, but rather a family of materials.

While more research needs to be conducted on the health effects of graphene, all the evidence collected so far suggests that graphene is not harmful to humans and is biodegradable within the human body.

We are also investigating the effects of graphene on the environment. The Graphene Flagship has collaborated with the European Commission's [REACH/ECHA](#) bodies to assess the material properties of graphene in all its forms and evaluate any health and safety or environmental issues associated with it.

What are the main achievements of the first 10 years?

Merely bringing graphene out of the lab and into commercial applications in such a short window of time is a great feat. Beyond that, the Graphene Flagship has created a real ecosystem for graphene research and innovation in Europe.

This also extends beyond the EU-funded partners of the Graphene Flagship. Our model, which includes associated members and partnering projects, has allowed us to include an even wider range of academic and industrial partners with whom to engage and collaborate. The long-term perspective and financial support received has been a crucial factor in facilitating this.

We have also been a remarkably good investment for Europe. For FET projects in general, the EU set a goal of generating 1 patent application per €10 million of funding. As of December 2023, the Graphene Flagship had reached 3.5 patent applications per €10 million.

Graphene Flagship also very largely exceeded the target for scientific publications. An economic impact report from the independent [WifOR Institute](#) found that the Graphene Flagship will have contributed €3.8 billion in GDP to the European economy between 2014 and 2030 and helped to create 38 400 jobs in EU countries.

What is unique about the Graphene Flagship?

The Graphene Flagship is unique among EU-funded projects for both its size and longevity. By having a single project covering the full spectrum of research into graphene and other 2D materials, it was possible to share data among a wide range of partners and avoid overlap and redundancies.

Importantly, having our funding guaranteed for a longer period allowed our partners to engage in more ambitious work. The longer time frame helped to build a real community for graphene research and innovation in Europe and gave space for trust to grow between partners. This facilitated collaborations and knowledge sharing which ultimately yielded greater results.

Over a period of 10 years we were also able to better assess the long-term impact of the project in a way that is not really possible with a typical three-year project.

Patents, for example, can take years to be approved and products need multiple iterations and safety checks before being ready for market. The Graphene Flagship had time to develop the technologies and to track their progress – ultimately with true benefit for European industry and society.

What does the future hold for the Graphene Flagship and 2D materials?

The Graphene Flagship now continues its journey in a new form under Horizon Europe. Under the umbrella of the Graphene Flagship, a budget of over €62 million is funding 12 ongoing research and innovation action projects working toward further advancements in the areas of energy, electronics and photonics, biomedical applications and composites, as well as on the development of new 2D materials.

We are also moving the [2D-Experimental Pilot Line](#) (2D-EPL) – one of the Graphene Flagship projects – to the next level with a proposal for a real pilot line which will transform how 2D materials are brought to application in Europe.

Furthermore, the [Innovative Advanced Materials for Europe](#) partnership (IAM4EU), drafted with input from both the Graphene Flagship community and the [Advanced Materials Initiative](#) (AMi2030), will now form a new Public-Private Partnership (PPP) under the second strategic plan for [Horizon Europe](#) for 2025-2027.

Through these ongoing developments, Graphene Flagship will continue to have an impact on Europe's green transition, the digital transition, and on building a more resilient, competitive, inclusive and democratic Europe.

The views of the interviewee don't necessarily reflect those of the European Commission.

More info

- [Graphene Flagship](#)
- [EU's future emerging technologies \(FET\) flagships](#)
- [EU research and innovation for chemicals and advanced materials](#)