Innovate UK
Technology Strategy Board

Results of competition: Realising the Graphene Revolution - Feasibility studies

Total available funding for this competition was £2.5m from the Engineering and Physical Sciences Research Council and Innovate UK.

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
2-Dtech Limited (lead) Evo Dental Centre Limited	Graphene-reinforced polymers for fixed dental prostheses	£199,550	£149,662
Project description - provided by applicants			
The project will explore the development of a robust manufacturing route for graphene-using technologies in the UK, in order to translate the unique material properties of graphene to composite materials used in dental prostheses. This is motivated by the requirement for novel materials used in dental restorations, which are to be resistant to mechanical failure, exhibit high levels of biomimicry and bacteria-inhibiting. The project will optimise the synthesis of these materials as well as evaluate their compatibility for function in their oral environment. A successful project will develop technology critical to reducing the increasing level of global edentulism as well as being transferrable to a further range of applications in the wider medical and materials science fields.			

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Results of competition: Realising the Graphene Revolution - Feasibility studies

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Applied Graphene Materials (lead) DuPont Teijin Films UK Limited	GraphFilm	£169,260	£119,936
Project description - provided by applicants			
This project involving Applied Graphene Materials, a rapidly growing start-up producing graphene nanoplatelets and dispersions, and DuPont Teijin Films, a leading polyester film manufacturer with a track record of innovation, will assess the feasibility of using graphene as a performance enhancer in polyester films. Dispersion techniques as well as polymerisation and coating methods will be investigated as possible routes for the incorporation of graphene in or on top of polyester films. The project will perform the first comprehensive characterisation of graphene containing polyester films including mechanical, electrical, thermal, chemical and barrier properties. This broad range of tests, matched with the available knowledge of commercial opportunities in the polyester film industry, will allow the partners to assess the benefits of graphene containing polyester films across a broad range of potential applications and to prioritise future development work.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Centre For Process Innovation Limited (lead) National Physical Laboratory – NPL Plastic Logic Limited University of Cambridge	GRAVIA - Contiguous graphene ultra-barrier films for flexible electronic applications	£199,570	£80,702

Project description - provided by applicants

The project will investigate the feasibility of producing very high quality barrier films in standard test formats for high quality flexible encapsulation of OLED and plastic logic display applications. These exhibit ultra low water vapour transfer rates (WVTR) of less than 1 X 10-6 g/m2 per day using self healing multilayers of high quality CVD graphene and Atomic Layer Deposited (ALD) amorphous alumina multilayers.

The work will explore the necessary industrial process parameters to ensure lowest price point at which the minimum barrier properties can be delivered. The resultant barrier films will be benchmarked against existing barrier coatings in WVTR and mechanical flex tests. The industrial innovation will be producing a fully flexible, self-healed (contiguous), optically transparent film of 25cm2 (beyond the current state of art 4cm2) using advanced characterisation and quality control metrologies to ensure iterative development.

The resultant understanding gained from the feasibility studies will be used to model and anticipate future larger film systems and will be also exploitated where possible by barrier seeking end users and through joint KTN activities to target these communities.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Coherent Scotland Limited (lead) Fraunhofer UK Research Limited	GraTi:S - Graphene for Titanium Sapphire Lasers	£118,711	£97,909
Project description - provided by applicants			
The UK has not yet realised the potential of the breakthroughs in Graphene. This high-risk feasibility project aims to pave the way for the UK's first flagship graphene-enabled product, a high-value ultrafast laser system for a variety of applications. This brings together two world leading organisations, Coherent Scotland and Fraunhofer UK to deliver a graphene subsystem which will to give greater functionality and reduced cost, enabling broader use and uptake of a headline export success for the UK. This will underpin and extend high-value employment lead to social and health benefits. Whilst early results in graphene suggest it has potential in optical applications, we propose to use it to provide a world first and leading product breakthrough.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
DZP Technologies Limited (lead) University of Warwick	Graphene electrodes for automotive supercapacitor energy storage (GRAPHELEC)	£199,944	£74,981
Project description - provided by applicants			
The GRAPELEC project will address the key questions about practical graphene performance in a real supercapacitor device. The consortium is led by DZP Technologies and University of Warwick – WMG. R&D activities include graphene inks production, electrode formulations and integration of graphene inks into electrodes for subsequent manufacturing of supercapacitor pouch cell. The targeted application of such a device is energy storage for low carbon vehicles. Other application areas can be anticipated in electricity grid balancing and consumer portable electronics. This project aims to benefit both academic and industry communities in the translation of technology discovered in the lab into the hands of industry. It will impact the UK energy storage communities by becoming potential leaders in the realisation of a technological-scale graphene-enabled supercapacitor pouch cell.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
EPL Composite Solutions Limited (lead) Haydale Graphen Industries PLC	Hydrogen Permeation improvements of thermoplastics using Graphene (HYPERGRAPH)	£198,680	£149,010
Project description - provided by applicants			
The aim of this project is to determine the feasibility of utilising graphene to improve the hydrogen barrier resistance of thermoplastics for the manufacture of high pressure hydrogen storage vessels. Carbon reinforced thermoplastic composite hydrogen storage vessels are currently being developed that will be fully recyclable, impact & fatigue resistant and more durable than is currently possible with metals and thermoset composites. Unfortunately some of the best performing polymers in terms of hydrogen permeation resistance are expensive, difficult to process and can have limitations in the amount of carbon fibre reinforcement that is capable of being used. The aim of this project is to develop methods to improve the hydrogen resistance of better-suited thermoplastic polymers and thermoplastic composites through the inclusion of functionalised graphene.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
European Thermodynamics Limited (lead) University of Manchester	GRAPHTED: Graphene nanocomposite materials for thermoelectric devices	£199,014	£74,948
Project description - provided by applicants			
The current climate for improved energy efficiency is driving the automotive market to seek ways of capturing waste energy from car exhausts. This will improve fuel consumption and reduce pollution while also reducing the levels of carbon dioxide emitted. Current materials for thermoelectric (TE) generators are typically based on compounds that are scarce, expensive and environmentally unsound. Other TE materials do not suffer from these drawbacks but their performance is insufficient to achieve technical and commercial viability. However, research at the University of Manchester has led to a number of innovative patent protected graphene containing materials with significantly improved thermoelectric properties over a wide range of temperatures. In collaboration with leading thermoelectric manufacturer, European Thermodynamics Limited, the GRAPHTED project will develop improved TE materials into waste heat recovery devices for automotive exhaust gas and other energy harvesting applications, significantly improving the efficiency and achieving cost-effective means to recover energy that would otherwise be lost.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
FormFormForm Limited (lead) Queen Mary University of London Foundation	Photo-responsive graphene for anti-corrosive and conductive strong, compliant silicone nanocomposites	£180,137	£69,027
Project description - provided by applicants			
A collaborative investigation into a novel method of processing graphene nanoplatelets for eased dispersion into polymer composites, this project seeks to exploit the exceptional electron and thermal conductive properties and gas barrier properties of graphene as a means of addressing a pressing, industrial problem with global implications, for which successful application would result in significant social, economic and environmental benefits.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
M-Solv Limited (lead) Printed Electronics Limited Thomas Swan & Co. Limited University of Surrey	G-Sense	£199,735	£97,779
Project description - provided by applicants			
The project consortium, which includes M-Solv (process developer and small-scale capacitive touch sensor (CTS) manufacturer), Thomas Swan (graphene manufacturer), Printed Electronics Ltd (inkjet ink formulator) and University of Surrey, aims to bring innovations to CTS manufacture. CTS comprises of structured transparent conductors (TC), which sense the capacitance variations when fingers approaches. Conventional CTS are made of TC, indium tin oxide (ITO), in which indium is known to be scarce and hence expensive in the near future. This project will explore the use of silver nanowire (AgNW), together with graphene to replace ITO for fabricating CTS at a much lower cost.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Nano Products Limited (lead) ESP Technology Limited Nottingham Trent University Thomas Swan & Co. Limited	Offset lithographic printing of nanocomposite graphene ink	£186,090	£104,017

Project description - provided by applicants

Offset lithographic printing presses are used to print glossy colour pages in magazines. The presses have many colour inks formulations which can be used to print a vast range of graphics on cardboard, paper and thin plastics.

This project will print graphene on to thin flexible plastic sheets, 1000mm by 707mm by 0.060 mm thick. Printed components will be used in printed electronics applications, as barrier layers for food and industrial packaging and electrodes for batteries, super capacitors and electrochemical sensors, toys and games, electronic anti-counterfeit labels and as the conducting layers in flexible photovoltaic devices and displays.

Because of the high quality and speed of offset lithographic printing there are likely to be significant cost reduction of flexible electronic devices and components, which will lead to lower prices. As well as established opportunities there is the strategic potential to print power harvesting, power storage, sensing, actuation, display and telecommunications devices on a single flexible substrate to enable SMART labels for tracking, healthcare diagnostics and wireless devices which hold information of interest to a customer.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Plastic Logic Limited (lead) Cambridge Graphene Center	HUG -Highly conductive Ultraflexible Graphene	£199,999	£75,012
Project description - provided by applicants			
The development of graphene technology that can be commercialized in the near and medium term is at the core of UK and world-wide investments. Demonstrators and proof of concept devices based on graphene technology have already shown the potential of graphene in flexible electronics. However, its practical application in end-user products such as foldable displays still needs to be proven. Graphene's processability on a large scale and integration in a functional active matrix is yet to be addressed. This project will evaluate the feasibility of using graphene dispersions as flexible conductive electrodes for plastic electronics, securing a new manufacturing route for foldable displays in end-user applications like smart phones and tablets. The end result of the project will be a flexible active matrix array using graphene as a flexible conductive electrode that can be used to drive electrophoretic (EPD) and organic light emitting diodes (OLED) displays.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Polyphotonix Limited (lead) Applied Graphene Materials CPI Innovation Services Limited	GraphTED - Graphene as a Transparent Electrode in Organic Electronic Devices	£199,965	£149,973
Project description - provided by applicants			
The partners will use graphene to develop novel ink formulations that can be used within printed electronic devices. The properties of the graphene layers deposited will be characterised in detail along with the properties of the printed electronic devices manufactured.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Sharp Laboratories of Europe Limited (lead) Thomas Swan & Co. Limited University of Manchester	Graphene enabled next generation battery technology	£184,295	£90,547
Project description - provided by applicants			
The project team Sharp Laboratories of Europe Ltd, Thomas Swan and Co. Ltd and The University of Manchester are developing Graphene based materials and sodium ion battery technology that will give improvements in sodium ion batteries for application in a range of enhanced electrical energy storage devices. The devices will have a significant impact on the introduction of local energy generation and consumption where improved energy storage and lower device cost are crucial to their future acceptability, and contribute towards reducing the UK's reliance on fossil fuels for domestic energy.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Smith & Nephew Extruded Films Limited (lead) Thomas Swan & Co. Limited University of Bradford	GraNet - Graphene / Polypropylene Composite Nets for Filtration	£174,838	£57,799

Project description - provided by applicants

This project uses Graphene to produce composites with polyolefins to give a step change in performance for lightweight extruded oriented products used in specialist applications. The project team will;

- gain an understanding of how Graphene can enhance the performance of polymer composites, especially in relation to physical strength and operating temperature.
- develop techniques to achieve dispersion of Graphene into a polymer matrix at production scale without damaging the platelet structure and reducing the benefits of addition.
- understand what impact Graphene has on polymer processability and rheological properties, including trials at production scale (processing up to 1kg of Graphene to produce 100kg of composite)
- model the impact that addition of Graphene has on product cost at predicted volumes.
- develop a value proposition for prototype products and gain feedback from customers in the target markets.