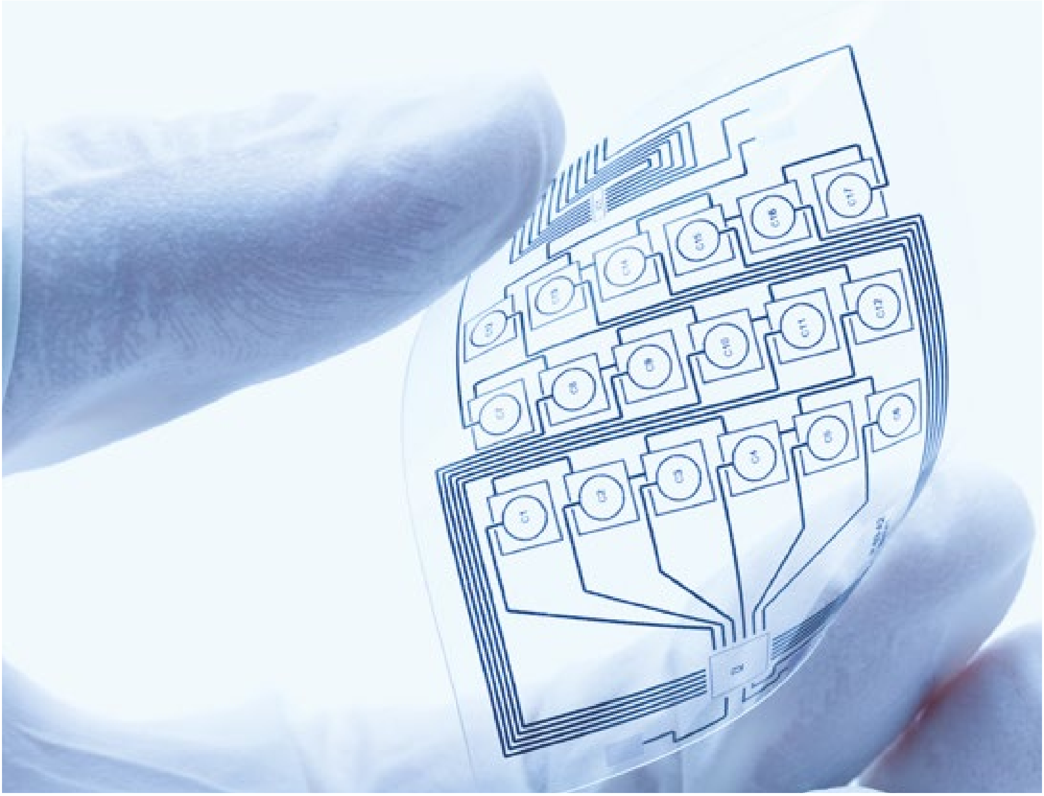


Research Councils UK

Advanced materials – a smart future

RESEARCH COUNCILS UK

Research funded by the Research Councils makes a vital contribution to the UK's economic growth, prosperity and well-being.

We take a variety of approaches to support innovation and deliver impact from research, including the development of collaborative research programmes, investment in major research capabilities, such as national research facilities, and the support of impact-related capabilities.

Often the impact of research is realised through the combination of several investments over time. The Research Councils seek to ensure that the outputs and outcomes of their funded research have significant long-term benefits for the economy and society. This timeline, one of a series, highlights how investments made in research over the long-term combine to create a significant impact in particular areas. In addition, research in one area can combine with that from another to drive innovation and provide a key contribution to UK growth. For example, the 2004 'discovery' of wonder-material graphene sparked a host of global research activity to further understand its extraordinary properties. The focus is now on how to exploit graphene. Just one atom thick, yet 200 times stronger than steel and an extraordinary conductor of electricity, graphene has potential across a wide range of applications, including electronics and optoelectronics, energy storage and advanced structural composites. It could potentially revolutionise the semi-conductor industry by replacing silicon.

A key part of the Government's Industrial Strategy is supporting technologies where the UK has the depth of research, expertise and the business capability to develop and exploit commercially. Advanced materials is one of 'Eight Great Technologies' identified by the Chancellor of the Exchequer in autumn 2012 when he announced an additional £600 million to help support their development. These eight are: Big Data and energy-efficient computing; Satellites and commercial applications of space; Robotics and autonomous systems; Synthetic biology; Regenerative medicine; Agri-science; Advanced materials and nanotechnology; and Energy and its storage.

Advanced materials – a smart future

Advanced materials are classified as completely new materials such as super-strong graphene, or developments of traditional materials such as lightweight metal alloys. These materials are essential to 21st century manufacturing in a UK market worth £170 billion per annum and representing 15 per cent of GDP[1].

Research is becoming increasingly focused on producing advanced materials with targeted properties, from novel high temperature superconductors to newly-developed polymer nanocomposites. Such materials have new or improved structural or functional properties and have applications across a wide range of sectors, including telecommunications, electronics, pharmaceuticals, aerospace, automotive, security and medicine.

Research Council support and investment in advanced materials has been active since the 1920s and continues to build on existing capability and excellence, bringing academia and business together to drive long-term economic growth and societal benefits.

For example, the first total hip replacement using High Molecular Weight Polyethylene (HMWP) was performed by Sir John Charnley in 1962. In 2008 aerospace engineers at the University of Bristol developed a new technique using epoxy resin to enable damaged aircraft to mend themselves automatically. The technique mimics healing processes found in nature.

The full potential of more recently discovered advanced materials such as graphene is still being realised, with the Research Councils investing in both the further exploitation of these materials and the research and development of future materials to build on the country's strength in this field.

[1] Eight Great Technologies, the Rt Hon David Willetts MP, Jan 2013

Health

1952: Dr Charles A Hufnagel implants the first artificial heart valve comprising a caged-ball, which utilises a metal cage to house a silicone elastomer ball.

1958: The first successful patch-graft angioplasty is produced using a polyethylene terephthalate graft.

1960s: Bioglass®, the first man-made material to bond to living tissues in a single attempt, is developed by Larry Hench.

1962: Sir John Charnley performs the first successful total hip replacement using High Molecular Weight Polyethylene (HMWP) as the socket material.

1991: Norplant®, a birth control drug consisting of small silicon capsules implanted under the skin and an early example of polymeric-controlled drug release, is commercially produced.

1999: Gliadel®, a degradable polymer wafer containing chemotherapy drug carmustine that is implanted in the brain to target brain tumours, is approved for use in the UK.

2001: University start-up company, ApaTech, formed to commercialise RCUK-funded research, develops a revolutionary synthetic bone graft material – today used by surgeons worldwide.

2002: Research Council scientists develop a fibre sourced from a species of wild silkworm that is proportionally stronger than steel and is as tough as Kevlar.

2006: A revolutionary dissolvable scaffold, made from polymers, is developed with the potential to provide a safer, more effective way of treating burns, diabetic ulcers and similar injuries.

2007: A hydrogel dressing is developed by RCUK-funded scientists at Aston University Biomaterials Research Unit and First Water Ltd to provide faster and more effective treatment for wounds.

2009: RCUK-supported scientists develop new silica coated quantum dots, as a step towards a sensitive biophotonic method for in vitro and in vivo applications.

2009: Research Council scientists produce electrospun biopolymer nanofibres, paving the way for future research into tendon repair.

2010: A new hydrogel material similar to that used in contact lenses is developed by a team of surgeons and materials scientists in Oxford, promising better treatment for cleft palates and for routine dental procedures.

2010: RCUK-supported physicists at the University of St Andrews develop a 'smart' material that could theoretically lead to the creation of a Harry Potter-style invisibility cloak. The material could potentially be attached to contact lenses to provide 'perfect' eyesight.

2011: RCUK-supported researchers at the University of Leeds develop a peptide-based fluid that, when painted onto a tooth that shows signs of decay, helps the tooth to regenerate itself.

2011: RCUK-supported scientists at the University of Birmingham create antibacterial coatings for stainless steel to help ensure hospitals are free from infections in the future.

2012: RCUK-funded researchers engineer scaffolds from biodegradable plastics for their potential use in combination with skeletal stem cells to replace lost bone in hip surgery.

2012: Research Council scientists use advanced implantable polymer PEEK-OPTIMA® in the production of a new orthopaedic implant considered to be stronger and more long-lived than the current generation of products.

2012: RCUK-funded scientists develop biopolymer hydrogels for use in the treatment of corneal blindness caused by limbal stem cell deficiency.

2013: Research Council-funded scientists develop a degradable polymer that can be inserted into broken bones to encourage real bone to regrow.

2013: Three-dimensional graphene foam is used for the first time as a scaffold for neural stem cells.

2013: Dr Ryan Donnelly wins the BBSRC Innovator of the Year competition for his work in developing microneedles made from a novel polymer which dissolve in the skin to deliver vaccines and other drugs without the need for traditional injections.

Electronics

1975: Researchers at the University of Southampton develop optical fibres that could transmit light over 100 kilometres with minimal loss.

1986: The detailed crystal structure of the first 'high-temperature superconductor', YBa2Cu3O7-x, is successfully determined at ISIS in 1986 using neutron diffraction.

1990: The crystal structure of C60 'buckyballs', the novel football-shaped form of carbon, is determined at ISIS in the early 1990s by diffraction experiments.

2003: The in-situ engineering testing facilities at ISIS lead to improved understanding of mechanical properties in a wide range of materials, from steels to shape memory alloys to rocks. Studies of piezoelectric ceramics lead to insights into the internal structure and behaviour of these smart materials, contributing towards their successful application as sensors and micromechanical actuators.

2004: 'Miracle material' graphene is first isolated, at the University of Manchester. Graphene is the lightest, strongest and most conductive material known to man, with great commercialisation potential due to its mechanical strength and unmatched properties as a conductor of electricity – allowing electrons to travel at near-light speed.

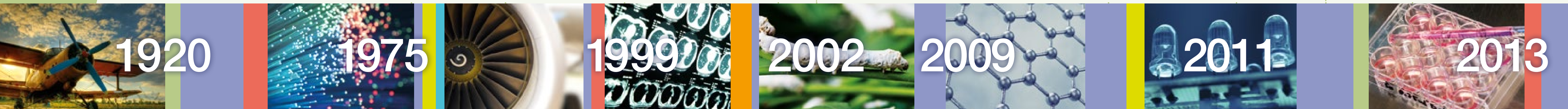
2010: RCUK-supported Manchester University scientists Professor André Geim and Dr Konstantin Novoselov are awarded the 2010 Nobel Prize for Physics for their ground-breaking work with the wonder-material graphene, which they discovered in 2004.

2011: By combining graphene with metallic nanostructures, Geim and Novoselov show a 20-fold enhancement in harvesting light using graphene, which paves the way for advances in high-speed internet and other communications essential for the evolution of modern infrastructure.

2012: The UK Government announces a £50 million investment to establish the UK as a global graphene research hub.

2013: Tiny LED lights being developed at UK universities led by University of Strathclyde could deliver Wi-Fi-like internet communications, while simultaneously displaying information, and providing illumination for homes, offices and a whole host of other locations.

2013: Plastic Logic, a company set up to commercialise RCUK-supported research, unveils the world's first flexible imaging sensor. Developed with ISORG, the sensor could lead to new ways to implement camera sensors in a wide range of products, including smart packaging, biomedical diagnostics, and surface scanners.



Transport and Fuel

1920s: Aluminium takes over from wood and canvas as the main material in aeroplane design.

1920s: Structural composites are first used in aircraft.

1940s: Nickel-based superalloys are developed for use in turbine blades in jet engines.

1964: British engineer Leslie Phillips develops carbon fibres and goes on to build the world's first carbon fibre production line for carbon composites.

1970s: Researchers at Rolls-Royce develop a method of growing whole turbine blades from a single crystal of super alloy, allowing the engine to operate at higher temperatures.

1970s: Researchers at Cranfield University help to pioneer the use of toughened epoxy resins.

1970s: Researchers at the Royal Aircraft Establishment in Farnborough (now QinetiQ) develop lithium-based aluminium alloys, which are around 10 per cent lighter than aluminium.

1980s: ICI produces one of the first thermoplastic composites, later pioneered by Westland for use in aircraft.

1990s: A University of Birmingham team develop a lighter-burn-resistant alloy based on titanium for use in aircraft engines.

2008: A new technique using epoxy resin that mimics healing processes found in nature is developed by aerospace engineers at the University of Bristol. The technique could enable damaged aircraft to mend themselves automatically. Other benefits include the potential to design lighter aircraft – leading to fuel savings and a reduction in carbon emissions.

2011: RCUK-supported researchers at the University of Surrey invent a new process to make bespoke 'ridged' plastic coatings that could one day reduce the drag resistance of ships and aeroplanes and thereby lower fuel consumption.

2012: The porous material, dubbed NOTT-300, is produced with support from RCUK. It has the potential to reduce fossil fuel emissions through the cheaper and more efficient capture of polluting gases such as carbon dioxide and sulphur dioxide.

2012: Scientists at the University of Oxford and Diamond Light Source describe a new chemical catalyst for producing methanol, a promising future biofuel. By reducing the energy needed to convert biomass to methanol, the new catalyst offers a more sustainable way to make the useful chemical and fuel.

Environment

2003: Nanomaterials slowly release ions to provide long-term marine antifouling performance as an alternative to the widely banned tributyltin antifouling compounds.

2006: The Environmental Nanoscience Initiative (ENI) is launched.

2008: Researchers can now visualise manufactured nanoparticles on the surfaces of fish gills using Coherent Anti-Stokes Raman Scattering (CARS).

2009: Facility for Environmental Nanoparticle Analysis and Characterisation (FENAC), based at the University of Birmingham, is launched.

2009: A new discovery about nanoparticle behaviour in sewage treatment plants will improve the environmental management of nanoparticle wastes from foods, cosmetics, medicines and other products.

2009: A new way of producing gallium nitride (GaN) using silicon wafers is developed by researchers supported by RCUK; it has the potential to produce energy-saving LEDs for a tenth of the current price.

2010: A miniature 'mimic membrane' on a chip that detects dissolved pollutants down to the nano-scale is licensed to Modern Water, a UK-based company specialising in protecting water supplies and wastewater treatment.

2011: The Transatlantic Initiative for Nanotechnology and the Environment (TINE) is launched, funded by a four-year grant from the UK Environmental Nanoscience Initiative and the US Environmental Protection Agency. For the first time, scientists from both sides of the Atlantic are joining forces to conduct research to determine the environmental behaviour, bioavailability and effects of manufactured nanomaterials in terrestrial ecosystems.

2011: RCUK-supported scientists create a new kind of solar cell that can be printed directly onto glass or glazing products, enabling them to generate electricity whilst also transmitting light. A spin-out company, Oxford Photovoltaics, is working to scale up the process.

2012: Plessey announces a commercial deal to manufacture affordable gallium nitride-based LED light bulbs, using a new technique developed by researchers at the University of Cambridge.

Advanced materials - a smart future

RESEARCH COUNCILS UK

The seven Research Councils are:

- Arts & Humanities Research Council (AHRC)
- Biotechnology & Biological Sciences Research Council (BBSRC)
- Economic & Social Research Council (ESRC)
- Engineering & Physical Sciences Research Council (EPSRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Science & Technology Facilities Council (STFC)

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Research Councils UK is the strategic partnership of the UK's Research Councils.

We invest annually around £3 billion in research. Our focus is on excellence with impact. We nurture the highest quality research, as judged by international peer review providing the UK with a competitive advantage. Global research requires we sustain a diversity of funding approaches, fostering international collaborations, and providing access to the best facilities and infrastructure, and locating skilled researchers in stimulating environments.

Our research achieves impact – the demonstrable contribution to society and the economy made by knowledge and skilled people. To deliver impact, researchers and funders need to engage and collaborate with the public, business, government and charitable organisations.

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