HENRY ROYCE INSTITUTE

The UK national centre for advanced materials

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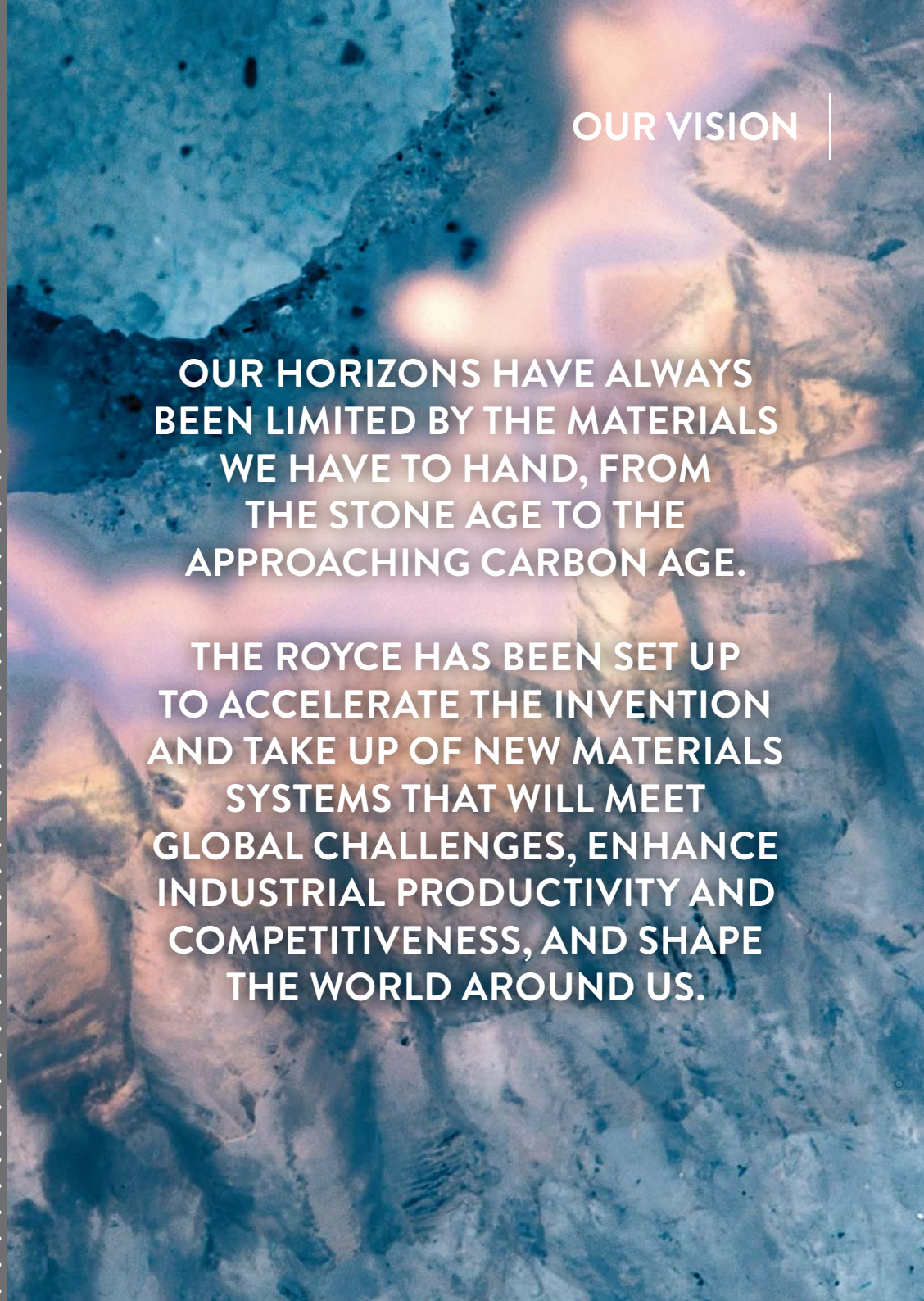


OUR VISION

OUR HORIZONS HAVE ALWAYS BEEN LIMITED BY THE MATERIALS WE HAVE TO HAND, FROM THE STONE AGE TO THE APPROACHING CARBON AGE.

THE ROYCE HAS BEEN SET UP TO ACCELERATE THE INVENTION AND TAKE UP OF NEW MATERIALS SYSTEMS THAT WILL MEET GLOBAL CHALLENGES, ENHANCE INDUSTRIAL PRODUCTIVITY AND COMPETITIVENESS, AND SHAPE THE WORLD AROUND US.

01
WELCOME TO THE ROYCE

The Henry Royce Institute is the UK national centre for advanced materials.

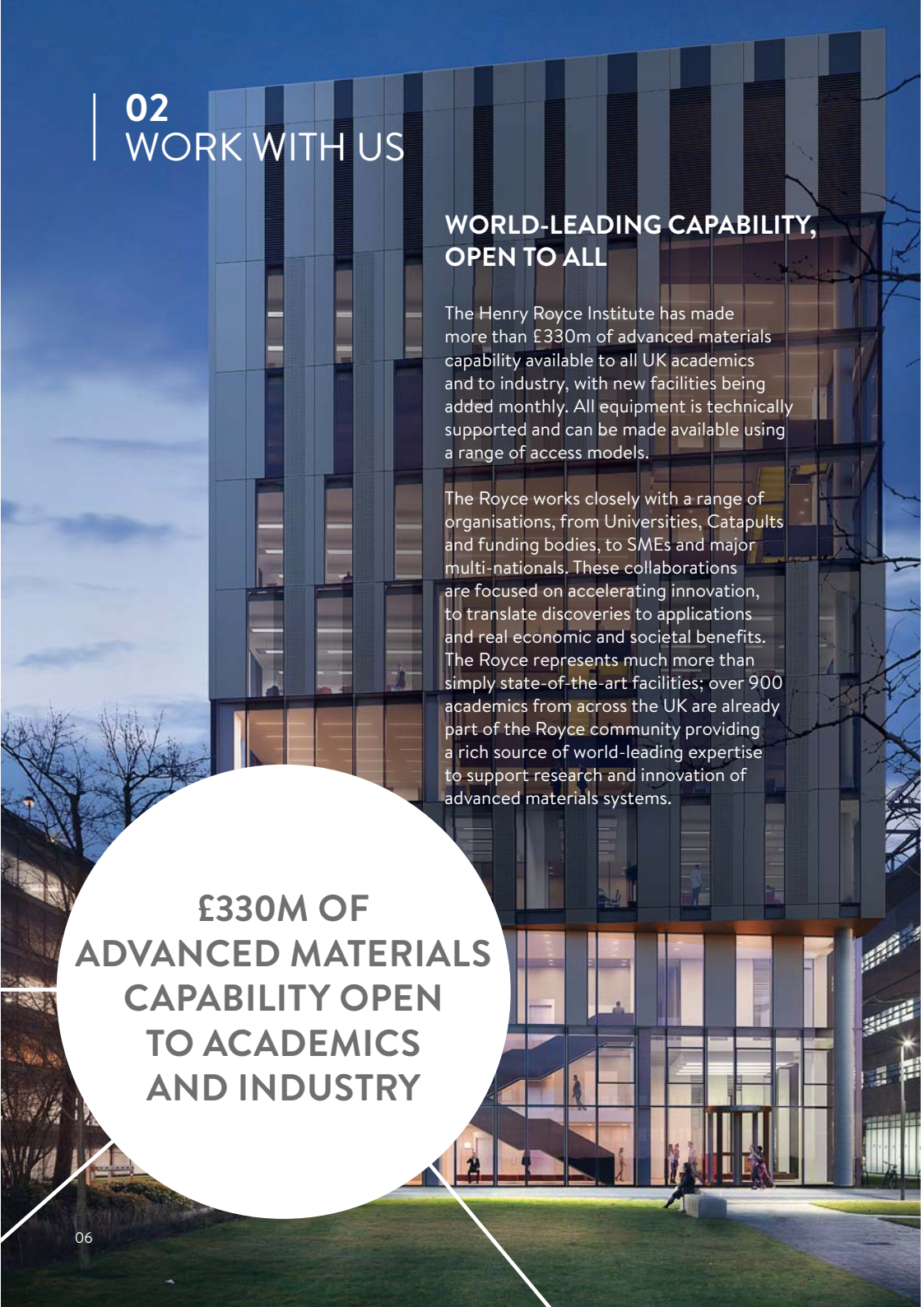
From future cities and their energy supplies, to computing, manufacturing and medicine, the Royce's research has the potential to have a significant impact that will be felt in people's everyday lives. The Royce was established to ensure the UK can exploit its world-leading expertise in advanced materials and accelerate innovation from discovery to application.

With its hub in Manchester and with capability distributed across nine founding Partners, the Royce is making a step change to research capability in the UK. It is open to all and supports both academic and industry research. Working collaboratively, the Royce aims to create real solutions and make a fundamental difference to the UK economy.

The Royce has identified nine critical research themes on which to focus its initial activity, ranging from Nuclear Materials and Energy Storage, to Advanced Metals Processing and Biomedical Materials. Each is championed by one of our Partners, who work with the wider academic community and industry to shape the research landscape.

Our vision is to create an integrated research supply chain in order to design, make and test advanced materials systems, cost-effectively and at speed. Whether you are from a large company, an SME or an academic environment, the Royce may be able to help and we look forward to working with you.

Phil Withers, Regius Professor and Chief Scientist, Henry Royce Institute



02 WORK WITH US

WORLD-LEADING CAPABILITY, OPEN TO ALL

The Henry Royce Institute has made more than £330m of advanced materials capability available to all UK academics and to industry, with new facilities being added monthly. All equipment is technically supported and can be made available using a range of access models.

The Royce works closely with a range of organisations, from Universities, Catapults and funding bodies, to SMEs and major multi-nationals. These collaborations are focused on accelerating innovation, to translate discoveries to applications and real economic and societal benefits. The Royce represents much more than simply state-of-the-art facilities; over 900 academics from across the UK are already part of the Royce community providing a rich source of world-leading expertise to support research and innovation of advanced materials systems.

£330M OF ADVANCED MATERIALS CAPABILITY OPEN TO ACADEMICS AND INDUSTRY

SUPPORTING ACADEMIA

Facilities at the Royce are open to all UK academics regardless of institution, using a fast access process.

All Partners have technical and advisory staff providing a single point of entry into facilities across the Royce, enabling you to easily find the right contact. Facilities can be accessed using a variety of funding sources, including research council grants. In addition there is funding available to support proof-of-concept research, and training and equipment use for PhD students.

The Royce can support individual research projects as well as contribute to larger programme grants, manufacturing hubs, European projects and national challenge funding.

SUPPORTING INDUSTRY

The Royce is open to businesses of all sizes, to help tackle materials challenges, exploit new opportunities, and accelerate research and innovation. From equipment access for commercially sensitive research, to long-term partnerships, the Royce can work flexibly and support a range of approaches and needs. These include:

- **Short-term contract research:** solving specific challenges or capitalising on opportunities, by accessing facilities and expertise
- **Long-term strategic research:** research programmes with broader focus that may also involve PhD funding, post-doctoral resource, consultancy and workshops
- **Knowledge transfer/training:** introducing knowledge and techniques into industry, its supply chain and SMEs
- **Innovation and roadmapping workshops:** activity focusing on scientific exploration of advanced materials challenges, foresighting and development of innovation strategies

The Royce is also able to fund SMEs to undertake proof-of-concept work and training.

To find out more, or to be connected with the most relevant expertise and facilities at the Royce, contact **info@royce.ac.uk**

FACILITIES INCLUDE MAKE, ASSEMBLE, TEST, CHARACTERISE AND IMAGING CAPABILITIES

INTERESTED?

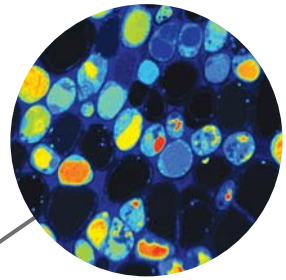
03 OPEN ACCESS FACILITIES

Together, the Royce Partners have established a unique, integrated UK capability to design from the 'atom to the component'. Over 900 pieces of equipment are available at the Royce and include make, assemble, test, characterise and imaging capabilities – allowing the iterative design of advanced materials systems with a wide range of applications across our research areas. These facilities support work across all Technology Readiness Levels (TRLs) with a particular focus on early TRLs.

Opening up a range of world-leading facilities is a significant investment in materials innovation in the UK. The Royce provides SMEs and spin-outs with access to research labs that were previously only available to major multi-nationals.

Our facilities are spread across the country and the Royce founding Partners, including equipment and expertise from:

- University of Cambridge
- Imperial College London
- University of Leeds
- University of Liverpool
- The University of Manchester
- National Nuclear Laboratory
- University of Oxford
- The University of Sheffield
- UK Atomic Energy Authority

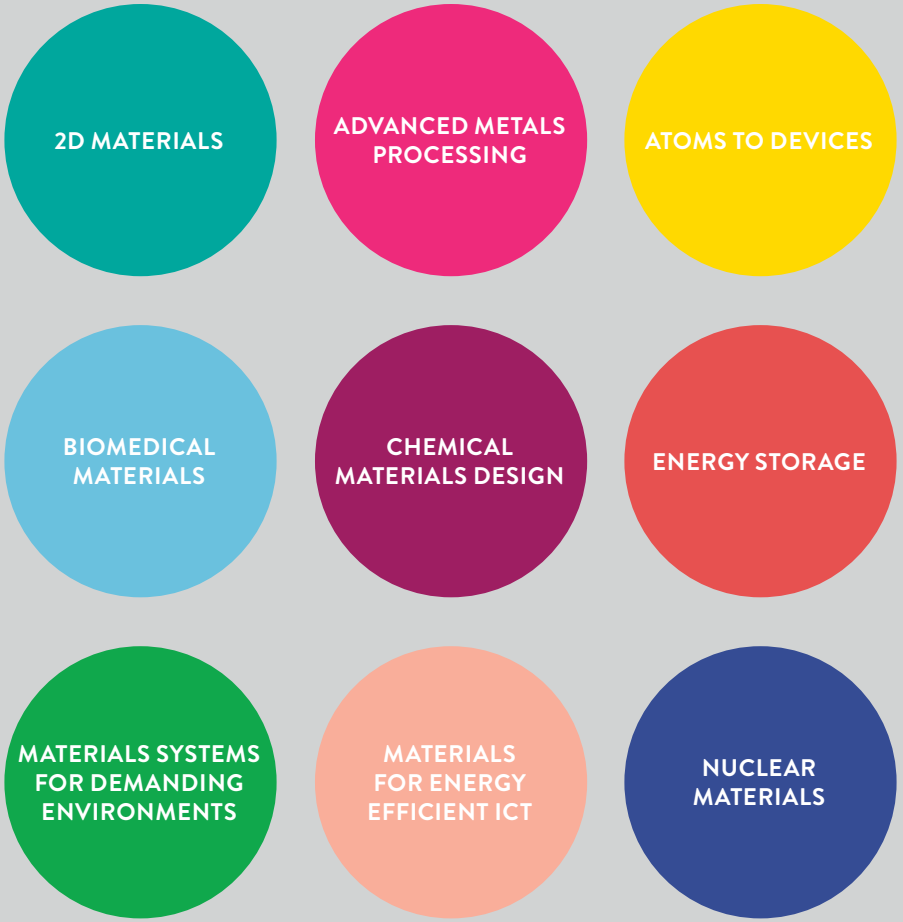


FIND OUT MORE

You can find an overview of the Royce facilities relevant to each research area later in this guide or, to browse and search a more detailed inventory, visit **royce.ac.uk**

Royce staff are available to discuss our facilities and equipment, based on your requirements, and can connect you with the relevant Partner institutions, technicians or academics.

04
RESEARCH AREAS



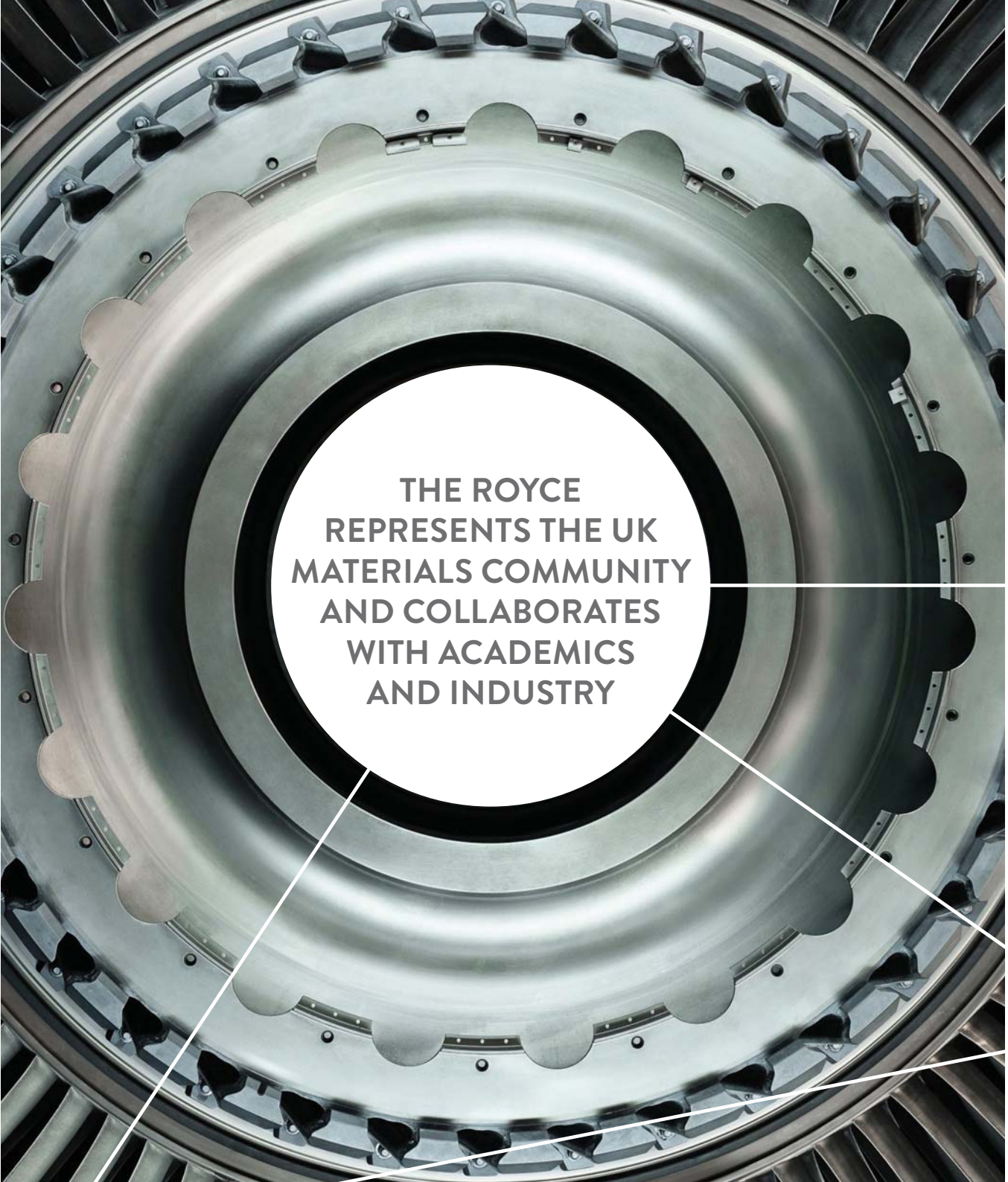
OUR RESEARCH SUPPORTS THE GOVERNMENT'S INDUSTRIAL STRATEGY TO DRIVE GROWTH

SUMMARY

In order to focus the Royce's research and deliver maximum impact, each Partner champions a core research area, providing leadership by working with related organisations in the field and identifying new challenges and capability gaps.

The Royce is aligned to the UK government Industrial Strategy and our research has the potential to transform the digital, engineering, energy and health sectors. Many of our research areas are complementary, and Royce Partner institutions work collaboratively, sharing facilities and expertise.

This section outlines at a high level the nine core research areas, their focus in terms of materials science and its application, and the most relevant equipment which is available to deliver these outcomes.



THE ROYCE REPRESENTS THE UK MATERIALS COMMUNITY AND COLLABORATES WITH ACADEMICS AND INDUSTRY

2D MATERIALS

Royce Champion

Professor Vladimir Falko,
The University of Manchester

Two-dimensional materials are one-atom thick materials capable of being combined in nano-stacks to deliver unique functionality. By far the best known is graphene, pioneered in the UK, but there is a large and growing family of 2D materials that promise to revolutionise the materials world.

The Royce focuses on developing the key underpinning science needed for future product development in a range of areas, including membranes for filtration and coatings, energy storage and functional composites.

The University of Manchester has established a suite for functionalisation of 2D materials with in situ characterisation/testing capability which, combined with existing infrastructure, will provide UK academic groups and companies with a single access point for the development, production and analysis of 2D materials. These materials will be exploited in inks for printable electronics, enhanced composites, coatings and membranes, and in electrodes in fuels cells, lithium-ion batteries and supercapacitors.

The National Graphene Institute at the University of Manchester houses 1,500 square metres of class 100 and class 1000 cleanrooms – the largest academic space of its kind in the world dedicated to graphene research – as well as laser, optical, metrology and chemical labs and equipment.

ADVANCED METALS PROCESSING

Royce Champion

Professor Mark Rainforth,
University of Sheffield

The Royce is focused on creating alloys with higher performance, better manufacturability, greater flexibility, lower cost, and lower environmental impact.

These new materials systems have a wide range of applications including: lightweight solutions for transport; net shape aerospace components; orthopaedic applications; additive repair of high value components; and primary metals for automotive and aerospace manufacturing. Our capability can make alloys at a scale that is relevant to research and to upscaling for industry needs.

The Translational Centre at the University of Sheffield acts as an open access centre of excellence, incorporating both existing and newly purchased state-of-the-art powder manufacture and processing facilities. The Centre enables Sheffield to lead on advanced powder manufacturing and processing, and to transfer knowledge and experience to local SMEs active in healthcare, energy, oil and gas, manufacturing and construction supply chains.

A second, new research centre, the Royce Discovery Centre at the University's city campus will be focussed on early-stage research in materials discovery and processing. The Translational Centre will then take these research discoveries and work with companies to help apply them to their manufacturing challenges.

ATOMS TO DEVICES

Royce Champions

Professor Neil Alford,
Imperial College London

Professor Edmund Linfield,
University of Leeds

The Atoms to Devices (A2D) area focuses on translating new materials systems from the atomic scale to operational devices. Research is supported by a range of capabilities, such as the manufacture of powders, deposition of functional films by vacuum or solution processes, and control of interfacial properties. This is complemented by theory and simulation capability, and facilities for structural, chemical and electrical characterisation. The Royce, together with the wider UK academic and industry community, has research excellence across the many disciplinary areas required to create an integrated Atoms to Devices programme.

The impact of innovation in this research area covers many applications, including: photonics, imaging and communication; semiconductors; cybersecurity; thermoelectrics; sensor technology; energy storage; and biomedical materials.

The new Bragg Centre at the University of Leeds will be home to Royce facilities and foster a culture of inter-disciplinary working in the development of novel materials to address 21st Century challenges. Imperial College London is also providing state-of-the-art facilities dedicated to the innovation of novel multifunctional devices, where researchers will have access to facilities for nano-scale thin film deposition, device patterning, and prototyping of nano-devices.

BIOMEDICAL MATERIALS

Royce Champion

Professor Sarah Cartmell,
The University of Manchester

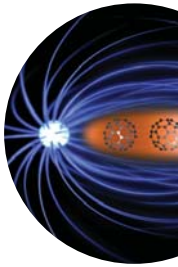
A new generation of "smart" biomaterials is required to support novel medical approaches that improve human health and well-being. The Royce will accelerate the discovery, manufacture and translation of these materials using state-of-the-art facilities.

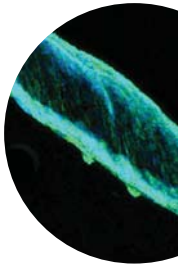
Two grand challenges have been identified: restoring biological function with minimal invasiveness (e.g. regenerative medicine, novel prosthetics and implants), and developing new therapies that reduce patient risk, improve efficacy, and lower cost (e.g. nanomedicine theranostics and personalised medicine).

Biomedical Materials focuses on providing direct patient benefit and improving medical testing and device production. Examples include replacing damaged tissues using only biodegradable biomaterials, and creating more devices that could be surgically inserted using minimally invasive techniques. In addition to having a significant global impact on healthcare provision, biomedical materials can create 3D in vitro tissues that improve pharmaceutical testing, and can also reduce the need for animal testing.

This research area is led by the University of Manchester, working with the University of Sheffield. Facilities at Manchester provide a suite to make, characterise and test biomedical materials and devices. This includes 3D printing, selective laser melting for powder production, mechanical analysis, cytometry, and light-sheet microscopy (LSM).

THE ROYCE WOULD LIKE TO GROW ITS PARTNERS TO INCLUDE AS MANY OF THE UK'S LEADING MATERIALS SCIENTISTS AS POSSIBLE





CHEMICAL MATERIALS DESIGN

Royce Champion

Professor Andrew Cooper,
University of Liverpool

The Royce will lead the discovery and analysis of new materials by collaborating with industry, and combining high-performance computing and materials science. Our research in Chemical Materials Design will have a significant impact on a wide range of industrial sectors, from nanofabrication to nuclear engineering. Applications for these tailored, novel materials are wide ranging and include the creation of sustainable structures for the power and transport industries.

The research area is led by the University of Liverpool, providing access to the new Materials Innovation Factory (MIF), and featuring open access laboratories which can be used by both academics and industry. Liverpool is investing £3m in automated robotic modules for formulation, chemistry and analysis. The 'Formulation Engine' will transform the process of testing and formulation, making it extremely affordable and accessible to industry and academic researchers.

The MIF draws together world-leading research and technologies, integrating computational and experimental models, and houses £10m worth of measuring and testing equipment. Royce facilities at the MIF include suites for chromatography, virtual reality and scanning electron microscopy (SEM), as well as a range of spectroscopy, light and x-ray scattering equipment.

ENERGY STORAGE

Royce Champion

Professor Peter Bruce,
University of Oxford

The Energy Storage research area is critical to our future cities and transport, both in terms of cost and efficiency, and environmental impact. Better energy storage materials are required for the electrification of transport and for the decarbonisation of the national grid. The Royce research area focuses on batteries, supercapacitors and thermoelectrics to solve the material challenges involved in the all-solid-state battery.

This research would transform the safety of lithium-ion batteries and enable the use of lithium metal electrodes to deliver a step change in energy density. This work can lead to safe electric vehicles with a greater than 300 mile driving range and faster charging. The global market in lithium batteries is growing exponentially, reaching £50bn in 2020.

The University of Oxford is providing a suite of state-of-the-art facilities and equipment focused on the analysis of energy materials and the development of energy storage solutions. This includes thin film deposition, UV-visible spectroscopy, dynamic light scattering, impedance spectroscopy, and electrochemical testing. The Royce is also collaborating with the Faraday Institution (FI), a new independent institute for electrochemical energy storage science and technology. A joint set of research priorities, between the FI and Royce, will be developed that exploits opportunities to their maximum potential.

MATERIALS SYSTEMS FOR DEMANDING ENVIRONMENTS

Royce Champion

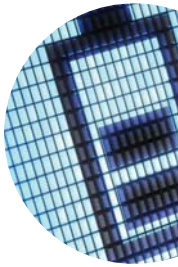
Professor Michael Preuss,
The University of Manchester

Corrosion is all around us, so understanding how materials systems behave in demanding environments is critical to safety and productivity. The applications of this research area are vast, covering energy production and the marine, aerospace and automotive sectors. Applications span a range of scales too, from small biomedical components that function in extreme and unusual conditions, to heavy engineering components such as infrastructure and transport.

The Royce enables the full design lifecycle for new materials systems, from design to make, and then characterisation and testing. This area has a large research capability in nuclear fuel cladding and high-pressure, high-temperature research, including a large autoclave testing facility.

A crucial aspect of developing these new materials systems is to fully understand the relationship between the manufacturing parameters and performance of the material; a cradle-to-grave approach. Imagine the benefit of turbine blade coatings which were self-healing, the environmental impact of errosion-resistant coated piping with sensor capability, or the economic and human impact of nuclear fuel assemblies that could withstand accident scenarios for hours instead of minutes.

Facilities at the University of Manchester include a tribology lab and the multidisciplinary characterisation facility, allowing researchers to work between different scales and modalities to investigate materials structure and failure mechanisms.



MATERIALS FOR ENERGY EFFICIENT ICT

Royce Champion

Professor Sir Richard Friend,
University of Cambridge

Current technologies, such as phones and tablets, operate below the scientific limits of performance. The Materials for Energy Efficient ICT research area focuses on innovation in energy generation, storage and use, which can have a transformative effect on the devices we use. The applications of this research can lead to a range of benefits for users, including advanced solar coatings to create self-charging devices powered by their environment, reduced power consumption, and significant improvements in battery energy density, longevity and cost.

This area is led by the University of Cambridge but works closely with a number of Royce Partners, including Atoms to Devices for materials nanofabrication, Chemical Materials Design for new functional materials, and large-scale Energy Storage research in Oxford.

The £25.6m Maxwell Centre at The University of Cambridge is home to Royce facilities, and is the centrepiece for industrial engagement on the West Cambridge Science and Technology Campus. The scale of industrial involvement is already substantial and the Centre provides working space and first class laboratories including magnetic property measurement, an electrical characterisation suite, electrochemical and energy storage testing, UV lithography, and nanoscale magnetic and thermal imaging.

NUCLEAR MATERIALS

Royce Champions

Professor Francis Livens,
The University of Manchester

Jonathan Hyde,
National Nuclear Laboratory (NNL)

Martin O'Brien,
UK Atomic Energy Authority (UKAEA)

The Nuclear Materials research area can be split into two areas: nuclear fuels and waste streams in the nuclear fuel cycle; and structural materials for fission and fusion energy. It will enable scientists and industry to prepare, test and analyse radioactive materials for fission and fusion applications, and substantial programmes of work on authentic irradiated nuclear materials.

Our researchers will deliver innovation in materials and understanding of their performance to reduce costs, underpin safety and increase productivity in current and future nuclear programmes. Themes of interest in this area include: fuel production and performance including accident tolerant fuel; waste conditioning and disposal; novel nuclear structural materials; and mechanical properties and irradiation effects in engineered alloys.

The University of Manchester's Dalton Cumbrian Facility provides access to ion accelerator systems and a gamma irradiator to support a wide range of in situ and ex situ experiments. This is complemented by capability at Manchester, the Culham Centre for Fusion Energy (UKAEA) and NNL for preparation and characterisation of irradiated and non-irradiated materials. Together our Partners provide world-leading expertise to help shape the UK's nuclear research agenda, enabling the UK to be a top-tier nuclear nation.

05
CONTACT

Contact the Royce to find out more about how we can help your organisation, and to discuss how our facilities and expertise can support your requirements.

To browse and search a detailed inventory of equipment, visit our website.

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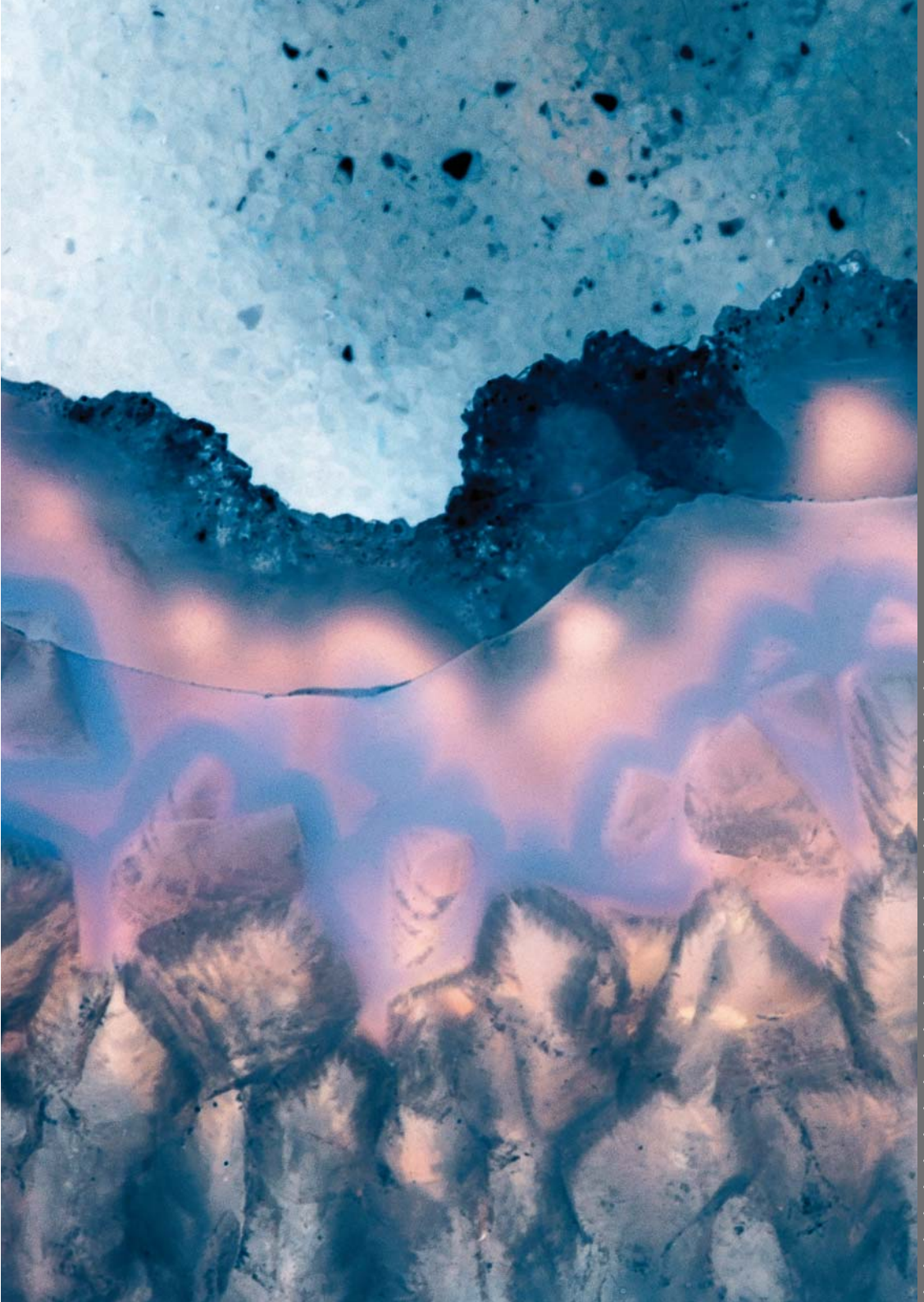

The University Of Sheffield.

UNIVERSITY OF OXFORD

MANCHESTER 1824
The University of Manchester

UNIVERSITY OF LIVERPOOL

UNIVERSITY OF LEEDS

UNIVERSITY OF CAMBRIDGE

NATIONAL NUCLEAR LABORATORY

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