HENRY ROYCE INSTITUTE

Welcome

To a large extent our horizons have been limited by the materials we have to hand, from the Stone Age to the forthcoming Carbon Age. Consequently, for the UK to remain globally competitive, we need to be at the forefront of the invention and application of new materials systems.

The Henry Royce Institute has been set up to ensure the UK is able to exploit its current world-leading expertise in advanced materials – providing a bridge between academia and commercial realisation. It will work across the range of technology readiness levels (TRLs), but particularly TRLs 1-5 and will provide national modelling, fabrication, testing, analysis and demonstration facilities. It will also be an international flagship and draw the best researchers and major investment into this rapidly expanding field.

The Royce aims to help shape the research landscape, and we have initially identified nine critical research themes on which to focus – each will be championed by one of our lead partners and we are looking forward to input from our academic and industrial stakeholders. The Royce also gives access to a portfolio of assets, including facilities and equipment.

Our vision is to create an interconnected research community that is supported by a research facilities ecosystem, providing an integrated research supply chain that works with facilities more widely across the UK to help provide the tools for world-class research to be advanced through the TRL levels.

We are only part way through our capital acquisition programme and so your help in determining future purchases will be appreciated as well as input on how we can help the UK gain most advantage from the kit we have. Whether you are from a large company, an SME or an academic environment, we would like to make sure our resources – and critically our research capability and people – are available to help you advance new and existing materials systems.

One of our aims is to provide SMEs and spin-outs with access to research labs that would normally only be accessible to a major multi-national – this will enable smaller enterprises to underpin their creative ambition with the necessary research infrastructure available on demand. Indeed, we look forward to exploring ways to open up our capability to all stakeholders.

Some of our assets are showcased in this brochure and hopefully this will help to provide a gateway to unprecedented research opportunities, but remember our real strength is our people so please don't hesitate to get in touch.

We hope you will find this information useful and will be able to take advantage of the expertise we have available. Please remember this is just the start of the Royce project so please keep an eye on our website for future capability acquisitions and help us to shape an exciting way forward.

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

Andrew Hosty, Chief Executive Officer, Henry Royce Institute

www.royce.ac.uk

Contents

To book: www.royce.ac.uk

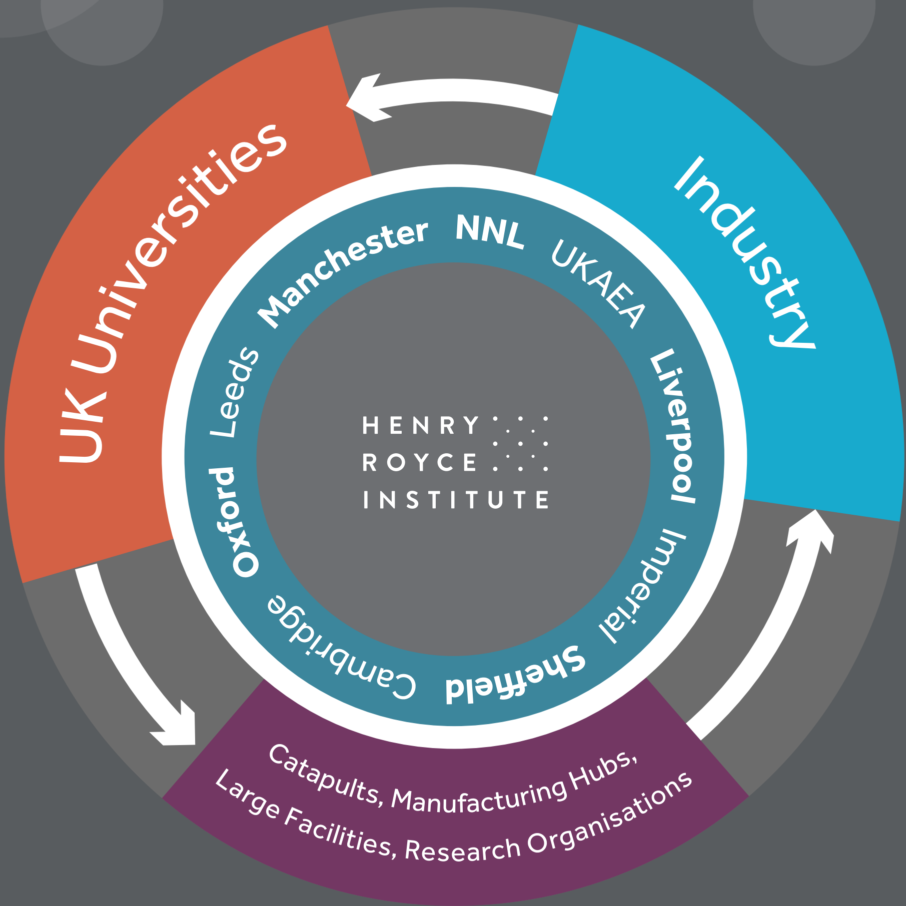
Introduction

Royce will invest in the UK's world-leading materials science research capability to stimulate commercial collaborations, generate societal benefits, and deliver positive economic impact for the UK.

Each founding partner is expected to:

- Act as a champion in support of the wider academic community in their chosen research theme
- Design and drive a strategic plan that is owned by this wider community
- Make equipment and facilities accessible to both industry and academia
- Collectively promote the Royce brand as the national body for advanced materials - with the key objective of fast-tracking discoveries to applications

To book: www.royce.ac.uk


UK Universities
Industry
Manchester
NNL
UKAEA
Liverpool
Imperial
Sheffield
Cambridge
Oxford
Leeds
HENRY
ROYCE
INSTITUTE
Catapults, Manufacturing Hubs,
Large Facilities, Research Organisations

Research Capabilities

The Henry Royce Institute is a national facility; its aim is to be a focal point for people to come and learn about materials science and develop it into a major economic force. Collaboration between world-leading researchers and companies will see real solutions, driven by research and making a fundamental difference to the UK economy.

£47m

the value of facilities and equipment lounges that are currently available

£25m

invested in new equipment that is currently available

£48m

the value of equipment to come

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Royce Facilities Funding

The Royce has been allocated a total of £235 million to invest in new equipment, facilities and buildings to underpin the UK's research base in advanced materials.

£187 million of the £235 million funding is now approved and being expedited by operational teams across the Royce funding partners.

The following pages provide a summary of the investment made to each partner since 2016 and those facilities which are currently "open for business". Further details are available at: www.royce.ac.uk

£114m

approved building

£23m

revenue to support facilities access and training

£235m

total Royce investment

To book: www.royce.ac.uk

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, but there is a large and growing family of 2D materials that promise to revolutionise the materials world.

This research theme is led by the University of Manchester but will bring together some of the UK's leading academics, from the universities of Manchester, Cambridge, Leeds, Sheffield, Imperial College London, Oxford and the National Physical Laboratory, who collaborate regularly to maintain the UK's leading expertise in 2D materials. Other institutions that are not currently part of the Henry Royce Institute, including the universities of Nottingham and Warwick, will also collaborate on the research.

2D MATERIALS

MANCHESTER 1824
The University of Manchester

HENRY ROYCE INSTITUTE


2D Materials

2D materials were pioneered in the UK following the isolation of graphene at The University of Manchester in 2004, and, since then, they have become the subjects of a massive international research effort due to their potential to influence a number of areas such as membranes for filtration and coatings, energy storage and functional composites. 2D material research at Royce will focus on developing the key underpinning science needed for future product development.

The University of Manchester will establish a suite for functionalisation of 2D materials with in-situ characterisation/testing capability which, combined with existing infrastructure at Manchester, 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. In the long term, this facility, in collaboration with the National Physical Laboratory, will lead the way in formulating standards for 2D materials, providing a crucial point of reference for the 2D materials supply chain in the UK.

To book: www.royce.ac.uk

2D Materials

Cleanrooms
@ The University of Manchester

The National Graphene Institute's cleanrooms provide over 1500m^2 of ISO standard 5 & 6 processing areas. This managed facility enables greater reproducibility and yield on nano-fabricated devices for front end research. It serves over 120 users from research organisations and industrial collaborators from around the world.

Capability

Photo-lithography suites

Electron Beam Lithography Suite inc. HiRes HiSpeed EBL (<6nM) on 200mm wafer

Clean Wet Chemistry space inc. HF/KOH suite

Atomic array prep areas inc. inert gas suite

Multi-Chem RIE suite

Multi-Chem deposition suite inc. ALD

Thin Film XRD suite inc. in-situ capability

UHV deposition

Characterisation suite inc. HiRES SEM, EDS, AFM, Raman, ellipsometry, surface profiling etc.

Atomic Force Microscope with in-situ analysis
@ The University of Manchester

Atomic force microscopy (AFM) gives sub-nanometer resolution of surfaces, providing information on their structure and physical properties, including morphology and mechanical behaviour. AFM is a particularly powerful tool for analysing 2D materials and a fast scan option allows rapid exploration of a large sample.

Applications include energy storage materials and electrocatylsts.

Specifications

JPK

Fast scan

Force microscopy

STM probe

In-liquid imaging

Potentiostat

To book: www.royce.ac.uk

Scanning electrochemical microscope
@ The University of Manchester

Scanning electrochemical microscopy measures the local electrochemical behaviour at a liquid-solid interface. This allows the redox behaviour of catalysts and energy storage materials to be investigated as a function of location.

Specifications

ic-SECM470 Intermittent Contact Scanning Electrochemical Microscopy

Applied potential and resolution ± 10 V FSR @ 32-bit (4.7 nV)

Measured potential and resolution ± 10 V FSR @ 24-bit (1.2 mV)

Minimum pulse duration: 100 ms

Scan rate: 1 mV/s to 200 V/s

Vibration frequency: 80 – 600 Hz

Thin Film X-ray Diffraction
@ The University of Manchester

X-ray diffraction (XRD) can be used to probe the repeating array of atoms that make up crystal structures. As a non-destructive technique, it can be used on the most precious of samples with high levels of reproducibility. Thin film XRD provides the sensitivity necessary to enable crystallographic characterisation of atomically thin films.

Specifications

SmartLab Multipurpose X-ray Diffraction System

Incident optics (supporting parallel beam, Bragg-Brentano, mono-chromator, range of slits (inc. Soller), pinhole configuration

Automated sample/X-ray alignment

Controlled heating stage >1000°C (inert atmosphere)

Temperature control stage (-100°C to 350°C) (inert atmosphere/vacuum)

Ability to measure air sensitive samples (>2 hours measurement time)

To book: www.royce.ac.uk

This theme will deliver a step change in the discovery and making of new material systems. Our researchers are creating alloys with higher performance, better manufacturability, greater flexibility and lower cost.

Led by The University of Sheffield, the core will be a joint activity between Sheffield and Manchester, and will also bring together some of the UK's leading academics with other Royce partners (Imperial College London, Cambridge, Oxford and Leeds) and those outside the current partnership (e.g. King's College London, Warwick, Swansea, Birmingham and Nottingham).

ADVANCED METALS PROCESSING

The University Of Sheffield.

HENRY ROYCE INSTITUTE

Metals production consumes about 5% of global energy use and is responsible for an annual emission of more than two gigatons of CO_2, so our systems will also have lower environmental impact – reduced CO_2, reduced reliance on strategic elements, designed for whole life cycle. Advanced Metals Processing will feature agile and lean manufacturing, which is flexible and tailored to customer requirements.

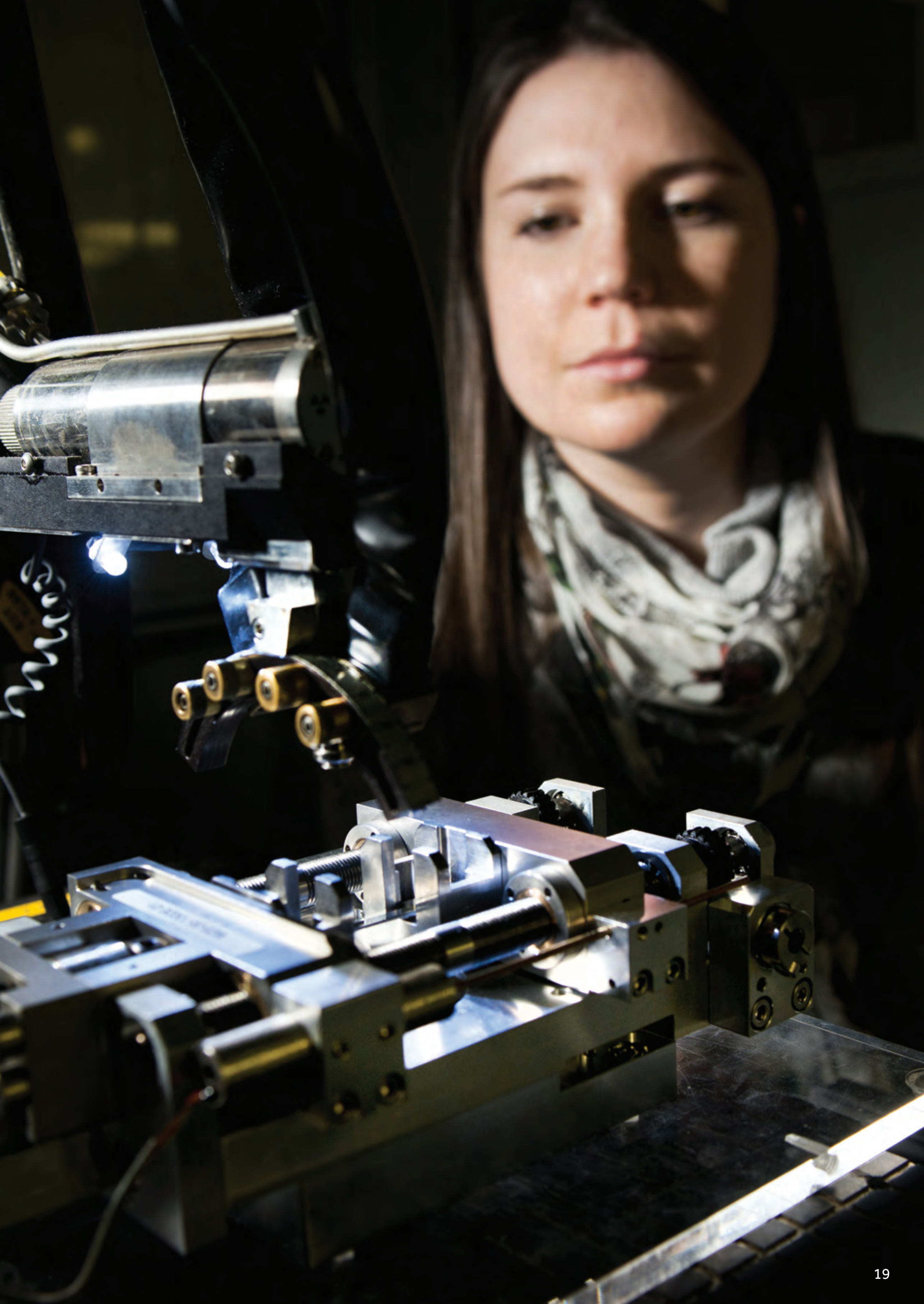
Our academics will have the ability to make alloys at a scale that is relevant to research and to upscaling for industry needs. Application areas include: Light weight system solutions for transport industry; New steels for nuclear industry; Net shape aerospace components; Additive repair of high value components; Materials tailored for orthopaedic applications; Primary metal suppliers for automotive manufacturers, aerospace component manufactures and gas turbine suppliers. The capability at Sheffield has been part funded by the European Development Research Fund.

At Manchester, AMP activity is focused around the Centre for Light Alloy Research Innovation (CLARI) which has obtained £5.9m EPSRC funding for the LightForm programme grant (in collaboration with Royce partners at Imperial and Cambridge) and has also developed an Airbus Research Partnership, underpinned by a Royal Academic of Engineering Chair and a newly appointed Airbus Fellow.

Activities such as LightForm, with an overall aim to provide UK industry with enabling research for a new holistic approach that will lead to a step change in the cost-effective production of more mass-efficient and recyclable light alloy components, have benefited greatly from the research capital infrastructure through Royce. This includes the procurement of a metal forming press, a fully instrumented dual-action hydraulic press for researching the formability of sheet metal under precise control and with full warm forming capability- essential for research in hybrid forming of aluminum and magnesium alloys, which require accurate temperature control during forming; future add-ons to the press would enable work on metastable titanium alloys, steel and other high-strength alloys.

Further AMP investment at Manchester to date includes equipment for thermal analysis and thermal mechanical simulation, such as a dilatometer, a high-temperature DSC, and an extensive Gleeble upgrade.

To book: www.royce.ac.uk



Advanced Metals Processing

@ **University of Sheffield**

Future facilities at Sheffield will be focused on materials manufacture and characterisation of those materials. On the manufacturing front, we anticipate installing scrap recycling processes, such as the use of continuous rotary extrusion to obtain high quality wire from swarf. A hot isostatic press will be available in 2018. There will be a multi-deposition system for alloy discovery. We will install an extreme environment ultra sensitive SQUID magnetometer and a FCT-HP D 250°C for fast sintering of powders up to 2200°C at 100-2500kN pressing force for component sizes up to 300mm diameter will be available in 2018.

Metal alloy production

@ **University of Sheffield**

A wide range of facilities have been installed to melt and cast metal alloys. Arc melting is available for the preparation of small batches of metal alloys, particularly high melting temperature systems. Our vacuum induction melting facility can melt up to 25kg of steel or Ni base alloys, or up to 3kg of titanium (skull melting). A hopper supply allows variations in alloy chemistry within one melting cycle.

Capability

Consarc single chamber vacuum induction melting facility for 25kg steel or 3kg titanium

Arcast Arc200 arc melting system to melt up to 500g of material. Includes bottom suction casting and continuous casting options

To book: www.royce.ac.uk

Part-funded by the European Union
European Regional Development Fund

Powder production
@ University of Sheffield

Facility to allow production of small batches (up to 10kg) of powder from a 50mm rod feedstock. The system uses drip melt feedstock to produce high quality spherical powder.

To further process powders and provide the highest possible powder quality, a spheroidisation system is available that improves flowability, reduces porosity and densifies the metal powder.

Capability

Arcast Powder Atomiser ATM DM50 to produce batches of powder up to 10kg from bar feedstock

Tekna Teksphero 15 powder spheroidisation system

Powder bed additive manufacturing
@ University of Sheffield

A range of powder bed additive manufacturing systems are available. State-of-the-art laser and electron beam systems have been installed in the Sheffield Royce facility. The systems allow both research into the additive process itself (open access code) and the manufacture of bespoke components.

Capability

Arcam Q20 and Q10 electron beam ALM systems

AconityLAB and AconityMINI laser based ALM

Associated powder recovery systems

To book: www.royce.ac.uk

Part-funded by the European Union European Regional Development Fund

Blown powder additive repair system
@ University of Sheffield

Layer by layer deposition in order to manufacture or repair, or to add functions and shapes onto existing components. The focus of the machine is to be able to undertake process control research in the repair of large aerospace components. With a large build volume and 5 axis control, the facility allows direct transfer of technology to the industrial scale.

Specifications

BeAM Magic 2.0 with a 2kW laser to build volumes up to 1200 X 800 X 800 mm using a 5 continuous axis machine-linear motor

Powder consolidation
@ University of Sheffield

FAST sintering allows the rapid consolidation of powders. The high heating rates and the applied pressure allow full densification of most materials in a matter of minutes. This results in substantially finer structures than conventional sintering and the ability to sinter materials that could not be processed by conventional means. It also opens up the possibility of manufacturing functionally graded materials.

Capability

FCT-SPS-1050 for fast sintering of powders up to 2100°C. Component sizes up to 80mm diameter

To book: www.royce.ac.uk

Part-funded by the European Union
European Regional Development Fund

Thermomechanical processing
@ University of Sheffield

Thermomechanical processing is an essential component of the manufacturing of most metals. The Fenn rolling mill allows the hot rolling of most metal alloys under well defined conditions of temperature, strain and strain rate. The Servotest plane strain compression machine is unique in its ability to simulate virtually any industrial hot rolling process to understand the correlation of key process variables (e.g. flow stress) and the microstructure produced.

Capability

Fenn rolling mill, model 081. Fully reversing rolling mill taking feedstock up to 70mm thick by 100mm wide with a maximum separating force of 136MT. The rolls can be heated to allow isothermal rolling of some materials

Servotest 400kN plane strain compression machine. Allows deformation at up to 1200°C, with strain rates up to 100s^{-1}, with multiple sequential deformation steps at defined temperatures and heating/cooling rates

Characterisation
@ University of Sheffield

Characterisation is essential to link the material properties with the process route. A wide range of characterisation tools are available to study the morphology, structure and chemical composition of a range of materials at length scales as small as atomic dimensions.

Capability

JEOL JEM-F200 Transmission Electron Microscope equipped with a cold field emission gun, high solid angle EDS, high resolution dual EELS and high speed cameras

Thermofisher ICP-MS

Agilent gas chromatography

PANalytical Empyrean X-ray diffraction system

To book: www.royce.ac.uk

Part-funded by the European Union European Regional Development Fund

Atoms to Devices is concerned primarily with the deposition of functional films either by vacuum (top down) or solution processes (bottom up) through patterning in all three dimensions. It also includes the manufacture of powders for thick film deposition. Potential application areas cover almost all industrial sectors and particularly ICT, Healthcare and Energy. These applications could transform the following markets: £360bn photonics/imaging/communication; £270bn semiconductor; £164bn Cybersecurity; £50bn energy storage.

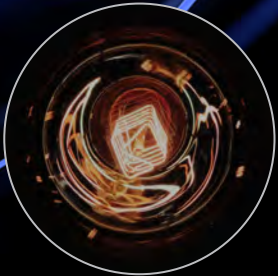
This research theme is led by the Imperial College London and University of Leeds, and brings together researchers from a number of Royce and other UK institutions. These include Sheffield, Liverpool, Manchester, Cambridge, Queen's University Belfast, Glasgow, York, Warwick and Edinburgh; along with central facilities (Diamond, ISIS, SuperSTEM).

ATOMS TO DEVICES

Imperial College London

HENRY ROYCE INSTITUTE

UNIVERSITY OF LEEDS



Royce academic partners, and the wider UK academic and industry community, have a vibrant, world-leading network in materials science and engineering, with excellence across the disciplinary areas required to create a vertically integrated Atoms to Devices programme. This interconnectivity is rarely seen in a single institution, and the Royce collaboration provides a unique and timely means of achieving this.

Atoms to Devices
@ **University of Leeds**

At the University of Leeds two new state-of-the-art facilities will be made available from mid 2018. Together they provide unique capability for the UK: a Multifunctional Materials Growth Facility, and a Versatile X-ray Spectroscopy Facility for Materials Characterisation in Controlled Environments. These complement the existing world-leading Leeds Electron Microscopy and Spectroscopy Centre and the Leeds Nanotechnology Clean Room Fabrication Facility. Together they enable the design of new materials, their characterisation, and their integration into devices. This new equipment will enable organic, ferromagnetic, piezoelectric, superconducting, and exotic topologically insulating materials to be combined with atomic resolution in a bespoke set of ultra-high vacuum chambers. This will enable electronic and opto-electronic devices to be designed in which the properties are controlled by manipulation of the atomic interfaces.

To book: www.royce.ac.uk

Multi-Chamber UHV Deposition

@ University of Leeds

The multi-chamber thin film deposition system is a state-of-the-art UHV suite of interconnected chambers optimised for growing extremely high quality materials. The distribution capability enables the cleanest possible interfaces to exploit the functionality that emerges through combinations of different materials. The bespoke system is designed by physicists whose long-term research interests have included extensive studies of growth optimisation.

Specifications

Four interconnected UHV chambers (with several expansion ports for future development):

UHV sputtering – 7 DC/RF guns and one RF off-axis gun, RHEED, masking tool for smaller samples;

MBE – for topological materials, 4 effusion cells, 2 cracker cells, 1 low temperature cell, RHEED and BANDITI;

Organics – 4 LTC effusion cells, 1 four-pocket e-gun, 1 sputtering gun, masking tool;

PLD – six targets with scanning facility, Coherent COMPexPro 205F laser, RHEED.

All chambers have a manipulator with substrate temperatures from 100K – 1500K. The maximum wafer size is 2".

Surface Analysis Facility

@ University of Leeds

The facility provides state-of-the-art analyses of a wide range of surfaces. We have a FIB system interconnected with SIMS allowing sample interchange without exposure to the atmosphere and whilst maintaining UHV conditions. Sample preparation facilities are available for top atom and molecule layer characterisation by LEIS and SIMS.

Capability

Time of flight secondary ion mass spectrometry (ToF-SIMS)

Low energy ion scattering (LEIS)

Focussed ion beam (FIB) microscopy with secondary ion mass spectrometry (SIMS)

Optical interferometry

To book: www.royce.ac.uk

Microscopy suite
@ University of Leeds

This suite of state-of-the-art microscopy capability is available to study the morphology, structure and chemical composition of a range of materials at length scales as small as atomic dimensions.

Capability

Titan 80/300 TEM/SEMJEOL 2000FX TEM

JEOL JEN-2100F TEMLEO Gemini 1525 FEGSEMJSM6400 SEMJSM5610LV SEM

Zeiss Auriga Cross Beam

Helios NanoLab 600

Atomic Force Microscopy

Versatile X-ray Spectroscopy Facility (VXSF)
@ University of Leeds

The Versatile X-ray Spectroscopy Facility utilises near-ambient pressure detectors, which have extended applications of X-ray spectroscopies far beyond surface analysis of solids, into all physical and life sciences as well as engineering. It will provide information on chemical composition and local structure (bonding, molecular orbitals, coordination geometry, electronic properties), with environmental control permitting monitoring of liquids, soft matter, and biological samples, as well as physical and chemical transformations.

Specifications

Bespoke XPS system, configured around a Specs EnviroESCA system including:

Ar cluster source; charge neutralisation; UHV XPS module with Al (monochromatic), Zr and Cr K_α sources and noble gas ion etching;

EasyXES 100

High pressure sample preparation chamber for sample transfer to UHV;

Sample transport devices ('suitcases'), linking to UHV, glovebox and cleanroom environments;

in situ and *operando* cells for synchrotron XAS, including environmental chambers for electron-yield and optical luminescence yield NEXAFS;

Crystallisers and liquid jet devices for probing of liquids with synchrotron X-ray absorption, X-ray Raman scattering, X-ray scattering and X-ray Pair Distribution Function measurements

To book: www.royce.ac.uk

Electron Microscopy and Spectroscopy Centre

@ Imperial College London

The Electron Microscopy and Spectroscopy Research Centre specialises in microscopic and spectroscopic characterisation of solid materials. The focus is on developing materials characterisation techniques to examine the morphology, structure and chemical composition of materials at length scales down to atomic dimensions. A particular specialism is in soft matter analysis.

Capability

Zeiss EVO MA15 VP-SEM and EDX

Tescan VEGA3 XM SEM and EDX/CL

FEI Quanta 650 FEG-SEM and HKL Premium Nordlys EBSD system

JEOL JXA-8230 Electron Probe Microanalyser

FEI Helios G4 CX DualBeam cryo-FIBSEM and EDX

Hitachi SU8230 FEGSEM and EDX

FEI Tecnai TEM G2 and EDX

FEI Titan Themis^3 300KV with Gatan OneVIew , EDX SuperX and EELS

Nanotechnology Cleanroom

@ Imperial College London

The Nanotechnology Cleanroom facility supports cutting edge research across the physical and life sciences, and includes 200 m^2 of ISO 5 and 30 m^2 of ISO 3 cleanroom containing state-of-the art equipment to suit most micro- and nano-fabrication requirements, including photo- and electron-beam lithography, deposition, wet and dry etching, post-processing and characterisation. Our team of dedicated experimental officers and technical staff is available to work with users to discuss and develop new processes.

To book: www.royce.ac.uk

Capability

JEOL 6300FS EBL; annealSys AS-One RTA

Plasmatherm Apex SLR ICP-RIE

Edwards Auto306 thermal evaporators

AML AWL Wafer bonder; EVG610 mask aligner

Ultratech Fiji F200 ALD ; ZEISS Leo 1530 FEG-SEM

Woollam M2000X spectroscopic ellipsometer

Loadpoint Microace 66 wafer saw

Heidelberg MLA150 maskless lithography

Logitech PM5 lapping station

Kurt Lesker PVD 75 sputterer

JFP S100 scriber & breaker

SciaMill 150 Ion Miller

Leybold Univex 350 e-beam evaporator

Plasmat Vision 310 PECVD

Thermal Analysis
@ Imperial College London

The behaviour of materials as a function of temperature is investigated in the Thermal Analysis facility. With the exception of dilatometry, where a solid specimen is required typical samples need only be a few mg and can be in bulk, powder or liquid form. All instruments have a nominal maximum temperature of 1500°C and experiments can be conducted under a variety of atmospheres.

Capability

Netzsch 'Jupiter' simultaneous DSC/TGA instrument

Netzsch 402E dilatometer

Stanton Redcroft 780 series, simultaneous DTA/TGA instrument

High Pressure Photoelectron Spectroscopy (HiPPES)
@ Imperial College London

X-ray photoelectron spectroscopy (XPS) and ultra-violet photoelectron spectroscopy (UPS) are fundamental techniques in the analysis of the surfaces of materials, providing key information on their elemental composition and electronic properties.

Specifications

VG Scienta R4000 HiPP-2 XPS/UPS analyser, MX650 monochromated x-ray source, VG Scienta VUV5000 monochromated UV source and FG300 flood gun for charge compensation

Sample analysis temperature = -140 to 1000 ˚C

Preparation chamber: Argon sputter, electron beam annealing and LEED optics

To book: www.royce.ac.uk

X-ray Diffraction (XRD)
@ **Imperial College London**

A wide range of X-ray diffraction techniques are available for the investigation of polycrystalline materials, single crystal and thin films. Samples may be examined in either bulk or powdered form.

Capability

2 PANalytical MRDs

Bruker D2 desk-top instrument for rapid data collection

Raith e-beam Facility
@ **Imperial College London**

The Raith e-Line electron-beam lithography facility provides a dedicated electron beam lithography system. This instrument directly patterns thin layers of resist by scanning an electron beam over the surface and can routinely achieve sub-20nm linewidth on PMMA resist.

A wide range of materials can be patterned using CAD software with minimum feature sizes around 10nm.

Flexibility and speed makes it an ideal tool for prototyping nano-devices.

Specifications

Resolution 20nm

Electron Beam resist processes

495 & 950 PMMA

Sample size from 10 x10mm up to 150mm diameter

To book: www.royce.ac.uk

Novel medical approaches to improve human health and well-being are essential for maintaining the UK's internationally leading position in medical technology. A new generation of "smart" biomaterials is required. The Biomedical Materials is a key theme within Royce and the intention is to accelerate the discovery, manufacture and translation of biomaterials through a platform of state-of-the-art equipment.

This research theme is led by the University of Manchester, working with Sheffield.

BIOMEDICAL MATERIALS

MANCHESTER 1824
The University of Manchester

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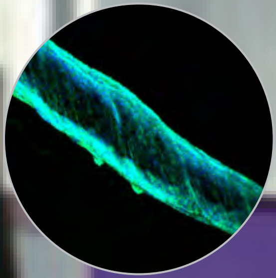

The two identified grand challenges of advanced biomaterials research are restoring biological function with minimal invasiveness (e.g. regenerative medicine, novel prosthetics and implants) and developing new therapies that reduce patient risk, improve efficacy, and lower cost (e.g. nanomedicine theranostics and personalised medicine).

This theme will deliver: Direct patient benefit by replacement of damaged tissues via regenerating worn out or torn cartilage using only biodegradable biomaterials; 3D in vitro tissues for improved pharmaceutical testing which could reduce reliance on antibiotics; Significantly reduce the need for animal testing; Reduce the overall cost of production of medical devices. Through improving the manufacturing process of currently used biomaterials and the creation of more devices that could be surgically inserted using minimally invasive techniques would have a significant global impact in terms of healthcare provision.

3D tissue manufacture and biomaterials mechanics evaluation suite

@ **The University of Manchester**

This versatile suite will allow culture of a variety of tissues and acelllular products ranging from heart valve tissue, blood vessels, ligament/tendon, bone, cartilage etc. and long-term cyclical fatigue testing of acellular biomaterial products that vary from hydrogels, polymers, elastomers (rubbers), ceramics, metals, composites etc. The suite will include the following kit from TA Instruments: 2 x Electroforce 5270 systems; Multi Specimen Fatigue System (3330 MSF); Planar Biaxial System; New 3310 system with an Extended Stroke actuator Electroforce 5500 system with 24 well fixture and 3D Culture Pro.

To book: www.royce.ac.uk

3D Discovery Bench-top Electrospinning
@ The University of Manchester

High performance and high resolution 3D cell-bioprinter with a unique modularity and flexibility for research and development. This equipment permits the spatially controlled deposition of multiple cell lines, cell-laden materials and biomolecules within tissue engineered constructs capable of mimicking the extracellular matrix (ECM) biophysical environment. A MESW kit is integrated for replication of multi-scale tissue features.

Specifications

Working platform 130 x 90 x 60 mm

Modular printhead technologies: ink-jet cell-friendly (non-heated); time-pressure printhead for paste and hydrogel dispensing

High speed CCD camera for droplet parameterisation

Software BioCADTM, BioCAMTM, BioCUTTM

MEWS with high voltage power supply (25kV) and heated material chamber heated up to 100°C

Quantitative cell imaging & analysis system
@ The University of Manchester

Automated quantitation of cellular behaviour on biomaterials and tissue engineering scaffolds is essential to compliment high quality imaging. This is a confocal based system with easily adaptable software to quantitate various parameters during live cell imaging over time. Processes include cell morphology changes, migration, differentiation, proliferation and aggregation.

To book: www.royce.ac.uk

Digital Fabrication Centre
@ The University of Manchester

Our range of inkjet equipment enables translation of basic and early stage applied research to higher technology readiness levels (TRL) by providing access to printing facilities compatible to those used in industrial production. The 3D printing suite covers several resolution levels and techniques including extrusion, inkjet printing and stereolithography. The dedicated support team has extensive experience in ink formulation and the use of inkjet printing and additive manufacturing techniques for a wide array of applications ranging from biomedical through to electronics.

Capability

Notion N.Jet with multiple head configurations, IR and UV pinning bar

LP50 with multiple head configurations

Dimatix DMP2800

SIJ-S030 Printer – Femtolitre drop volume

Microfab jetting platforms

Stratasys Objet30 Pro

3D systems, Viper si2

3D Discovery Biosafety Evolution
@ The University of Manchester

This is a state-of-the-art bioprinting platform for multi scale and multi material printing of 3D functional tissue constructs. The system integrates two different printhead technologies (cell-friendly inkjet and polymer extrusion), allowing for biomimicry of the native biological microenvironments through spatial control of cells, bioactive molecules, and biomaterials. A Melt Electrospinning Writing (MESW) kit is incorporated for micro and sub-micrometer manufacturing.

Specifications

Biosafety cabinet class A2

Working platform 130 x 90 x 60 mm

Printhead resolution ± 5 μm

Non heated cell friendly printhead for jetting or contact dispensing (viscosity 100-1000 mPa.s)

Thermo polymer extruder with material container heated up to 240 °C (viscosity 1000-10000 mPa.s)

High speed CCD camera for droplet parameterisation

Software BioCADTM, BioCAMTM, BioCUTTM

MEWS with high voltage power supply (25kV) and heated material chamber heated up to 100°C

To book: www.royce.ac.uk

ZEISS Lightsheet microscopy (LSM)

@ **University of Sheffield**

LSM permits micron resolution of three-dimensional analysis of several mm using advanced prototype 3D in vitro cell-based assays. Their application is pertinent to the rapid development of three-dimensional cell and tissue culture, of which novel biomaterial scaffolds form an integral component.

Specifications

Sample positioning four-axis multi-coordinate stage with stepper motors

Laser class: 3B

Laser wavelengths and power:

405nm 20mW or 50mW

445nm 25mW

488nm 30mW or 50mW

515nm 20mW

561nm 20mW or 50mW

638nm 75mW

In vivo / in situ confocal imaging microscopy (IV-CIM)

@ **University of Sheffield**

IV-CIM is a novel technology that enables cellular and subcellular images of any tissue to be determined by direct contact in 3D in vitro constructs or in vivo. Optical slicing can be conducted at multiple time points for high throughput monitoring. This has multiple applications of relevance across neuroscience, cardiovascular, musculoskeletal, stem cell, alimentary and epithelial / stromal research.

Specifications

Cellvizio dual band

Excitation wavelengths: simultaneous 488 nm and 660 nm

Collection bandwidths: first line 502 - 633 nm; second line 673 - 800 nm

Resolution: between 3.3 and 1.4 μm

Real-time video recording frame rate: 9-18 fps advanced mode: 40 fps

Operating system: Linux Ubuntu

Laser class: 3R

Combining high-performance computing and materials science, collaborating between academia and industry, will be a game changer for the discovery of new materials and their analysis. The Royce research will have a significant impact on a wide range of industrial sectors, from nanofabrication to nuclear engineering. In the future, it will involve engineers and scientists working together to tailor novel materials to create sustainable structures for the power and transport industries. Royce facilities, which are located in the new Materials Innovation Factory at Liverpool, will feature open access labs which can be used by both academics and industry.

This research area is led by The University of Liverpool.

CHEMICAL MATERIALS DESIGN

UNIVERSITY OF LIVERPOOL

MATERIALS INNOVATION FACTORY

HENRY ROYCE INSTITUTE

Automation
@ University of Liverpool

Liverpool is investing £3 million in developing a number of highly versatile, automated robotic modules for formulation, chemistry and analysis. The modules can operate collaboratively by docking within the "Formulation Engine" a 10m x 2.7m platform which will allow multiple workflows to operate simultaneously, and will provide a high level of working flexibility. The high-throughput ability of the Formulation Engine will transform the process of testing and formulation, whilst making it extremely affordable and accessible to industrial and academic researchers. After a competitive tender process, Labman Automation Ltd was chosen as our technology partner to design and build the platforms. The build phase is now well under way with delivery expected in late 2018.

Chromatography Suite
@ University of Liverpool

Combining the separation, identification and quantification properties of chromatography with the sensitivity of mass spectrometry is paving the way to new and exciting discoveries in materials science. We are investing in an advanced chromatographic suite to ensure we remain at the forefront of advances in chemical materials design. This suite will consist of advanced liquid chromatography mass spectrometry (LC-MS), gas chromatography mass spectrometry (GC-MS) and supercritical fluid chromatography (SFC). Each piece of equipment has been specifically tailored to meet the highest possible standard of performance currently available from a range of world leading manufacturers in the field of chromatographic scientific equipment.

To book: www.royce.ac.uk

Cryo-SEM Suite
@ **University of Liverpool**

The University of Liverpool is investing in a state of the art high resolution scanning electron microscopy (SEM) suite, which will combine a focused ion beam (FIB) with a SEM and a cryo stage to enable the analysis of solid and liquid samples. This suite will incorporate energy dispersive spectroscopy (EDS) and wavelength dispersive spectroscopy (WDS) detectors, which are both powerful techniques in the study of organic and inorganic materials. The addition of a FIB allows the preparation of TEM Lamella for solid samples, with the future ambition to develop TEM lamella of liquid samples allowing for the analysis of cross sections of formulations and nanomaterials.

Virtual Reality (VR) Suite
@ **University of Liverpool**

As projects become more complex and the chemical, biological, material and mechanical systems under analysis become increasingly large scale, the problems of data and system visualisation become increasingly difficult. The virtual reality suite bridges this gap by displaying data in a truly interactive and collaborative environment, each person can bring their own expertise to bare on the project and highlight the region of the system where their expertise is relevant and gain a general understanding of the full system. The virtual reality suite will offer an exciting and new method for single investigators or collaborative groups to visualise their systems and data in new and illuminating ways.

To book: www.royce.ac.uk

SYNAPT G2-Si Imaging Mass Spectrometer
@ **University of Liverpool**

Matrix assisted laser desorption ionisation (MALDI) provides excellent spatial resolution and is an established MS ionisation approach. The desorption electrospray ionisation (DESI) option requires minimal sample preparation and excels at lipid and small molecule imaging. The non-destructive nature of this technique enables the samples to undergo further analysis which is of interest for precious or highly expensive samples.

Specifications

Enhanced selectivity from unique ion mobility separation

Versatile experimental options

High performance accurate MS and MS/MS

Choice of MALDI, DESI and ESI

Autoflex MALDI-ToF Mass Spectrometer
@ **University of Liverpool**

The sample (approx. 2.0 mg) is mixed with an excitation matrix and recrystallized onto a target plate. A laser is fired at the matrix/sample crystal and the sample travels down a time-of-flight tube to the detector where the mass:charge ratio (m/z) is measured. MALDI-ToF is suitable for a wide range of samples from intact proteins to polymers. Matrix selections is key to obtaining good results. It is a destructive technique.

Specifications

MALDI perpetual ion source

Pulsed ion extraction

Bruker Smartbeam technology

MS/MS capability

ToF analyser for linear and reflectron measurements

Ground steel, anchor chip and polished steel target plates

High mass ranges (up to 26,000)

To book: www.royce.ac.uk

inVia Confocal Raman Microscope

@ **University of Liverpool**

Raman is a spectroscopic technique that uses monochromatic light and inelastic scattering to observe vibrational and rotational modes in a sample. It is based on a change in polarizability, whereas FT-IR requires a molecule to undergo a dipole change. For example, symmetrical molecules do not have IR absorption but will produce Raman scattering.

Specifications

Renishaw InVia Confocal Raman Microscope

532 nm and 785 nm laser

10x, 50x and 100x standard objectives

100x oil immersion and 63x water immersion

Live Focus Tracking

WiRE 4.4 software

StreamHR software

Hot and cold stage

96 well-plate attachment

Macro sampling kit

Vertex 70 FT-IR

@ **University of Liverpool**

Fourier transform infrared (FT-IR) spectroscopy is widely used in both industry and academia due to its speed and precision for structural information such as including functional group identification. A diamond attenuated total reflectance (ATR) and a germanium ATR are available for solid, liquid and film samples. A 96 well plate reader is also available. The FT-IR has two different detectors, the deuterated triglycine sulfate (DTGS) and the mercury cadmium telluride (MTC) enabling rapid measurements.

Specifications

Bruker Vertex 70 FT-IR Spectrometer

DTGS and MTC detector

OPUS software

Diamond crystal ATR

Germanium crystal ATR

Transmission accessory

96 well-plate attachment

To book: www.royce.ac.uk

Fluorescence Lifetime Spectrometer (FLS1000)

@ University of Liverpool

Fluorescence lifetime spectrometry (FLS) can be used to measure the excitation and emission spectra of liquid or solid samples. This FLS100 has a very low limit of detection allowing very weak (<100fM) samples to be analysed. The instrument can also be configured to perform Time-Correlated Single Photon Counting (TCSPC) to measure the lifetime of fluorescence.

Specifications

Edinburgh Instruments FLS1000

200-870 nm wavelength range

Signal to noise ratio >25,000:1

Rapid measurements <30s

Sample holders for liquids, films and solids

Full Fluoracle software

Advance FAST software available for detailed

TCSPC analysis

UV/VIS/NIR Spectrophotometer

@ University of Liverpool

UV/Vis/NIR spectrophotometry can characterise a wide variety of samples from liquids in cuvettes to translucent thin films and even opaque solids between 175-3300 nm. This instrument can measure the absorbance (up to 8.0 Abs) or the reflectance of a sample using the internal diffuse reflectance accessory (DRA).

Specifications

Agilent Cary 5000

175 -3300 nm wavelength range

Up to 8.0 absorbance units

Variable slit widths down to 0.01 nm

Sample holders for liquids and films

Internal diffuse reflectance accessory (DRA) for measurement of reflectance of solid samples

Full WinUV software suite for: Colour, Concentration, Dissolution, Simple scans and full spectral scans

To book: www.royce.ac.uk

Mass Directed Preparative HPLC
@ University of Liverpool

This HPLC has two different detectors: a diode array detector (DAD) capable of measuring up to 8 different wavelengths (range 190-600 nm) simultaneously, and a mass spectrometer (MS) capable of measuring m/z ratios up to 2000. Two preparative pumps are each capable of delivering up to 50 mL/min at 400 bar pressure enabling large bore semi-prep columns to be used.

Specifications

Agilent HPLC

Columns available:

Zorbax SB-CN 2.1 x 150 mm 1.8 µm

Zorbax SB-C18 4.6 x 50 mm 5 µm

Zorbax SB-C18 9.4 x 250 mm 5 µm

Zorbax SB-C18 4.6 x 250 mm 5 µm

Zorbax SB-CN 4.6 x 250 mm 5 µm

Poroshell 120 EC-C18 4.6 x 100 mm 4 µm

Zorbax SB-C18 9.4 x 50 mm 5 µm

Zorbax SB-C8 2.1 x 50 mm 5 µm

Zorbax Eclipse Plus C18 4.6 x 100 mm 3.5 µm

Drop Shape Analyser DSA100E
@ University of Liverpool

This is a fully automated instrument for the measurement of contact angles of solids using the sessile drop method and of surface tensions using the pendant method. It can can dispense 1-200 µL volumes onto millimeter (mm) sized samples or conversion to the micro system allows smaller doses of 20 pL to be dispensed onto samples in the micrometer (µm) range.

Specifications

Kruss DSA100E

Software controlled x,y,z stage

Software controlled dosing unit

Camera with 1200 x 800 pixels at 200 fps

Both surface contact angle and surface tension analysis

The micro system enables 20 pL dosing onto micrometre sized substrates

Fibre holder for samples up to 700 µm in diameter (for example single hair fibres)

To book: www.royce.ac.uk

Mastersizer 3000
@ University of Liverpool

This is a static light scattering (SLS) technique in which a dispersed sample is illuminated with lasers and a series of detectors accurately measure the intensity of light scattered by the particles. It can measure the particle size of wet samples (samples within a suitable dispersant) within the 10 nm-3.5 mm range or dry samples (samples dispersed in an inert gas) within the 1-3500 µm range. A range of dispersion units are available depending on the volume of sample (5.6 mL up to 1000 mL.).

Specifications

HydroSight allows visualisation of sample dispersion

Accuracy >0.6%

Precision/Repeatability >0.5%

Analysis via Mie or Fraunhofer scattering

HydroSV: Dispersion unit for small volumes (5.6 mL)

HydroMV: Automated wet dispersion unit for medium sized samples (120 mL)

HydroEV: A dip in wet dispersion unit for larger volumes (800/1000 mL)

AeroS: A dry powder dispersion unit for cohesive powders to fragile materials

Zetasizer ZS
@ University of Liverpool

This is a dynamic light scattering (DLS) technique measuring the diffusion of particles moving under Brownian motion which is converted into size using the Stokes-Einstein relationship. It has the ability to measure particle size in the 0.3 nm-1 µm range within a suitable dispersant. This instrument can also determine the zeta potential of 3.8 nm-100 µm particles and the zeta potential of solid surfaces using the surface zeta potential kit.

Specifications

0.3 nm-1 µm measurement range

Minimum sample volume 12 µm

Accuracy +/-2%

Precision/Repeatability +/-2%

NanoSampler for automated sample loading

MPT-2 for automated measurement of pH and conductivity

Range of zeta potential sample holders

To book: www.royce.ac.uk

Small Angle X-Ray Scattering (SAXS)
@ **University of Liverpool**

This system is capable of characterising the nanostructures of both solid and liquid samples, ranging from 1 nm to roughly 125 nm providing shape, size distribution and distance apart information. The Nanostar enables rapid measurement speed due to a gallium liquid X-ray source. It is a non-invasive/non-destructive technique requiring little to no sample preparation allowing in-vivo and in-situ measurement.
A temperature controlled stage is also available.

Specifications

Bruker Nanostar

Motorised x,y stage

Detector to sample distance from 11.5 mm to 1070 mm covering SAXS and WAXS

GISAXS sample stage

Heating/cooling stage

Measurement in gas atmosphere

To book: www.royce.ac.uk

What if we were able to solve the material's challenges involved in the all-solid-state battery? It would transform the safety of Li-ion batteries; enable the use of lithium metal electrodes delivering a step-change in energy density, leading to safe electric vehicles with a more than 300 mile driving range and faster charging. The global market in lithium batteries is growing exponentially, reaching £50bn in 2020. The UK will require the equivalent of two gigafactories for electric vehicles alone by 2025.

This research area is led by The University of Oxford.

ENERGY STORAGE

UNIVERSITY OF OXFORD

HENRY ROYCE INSTITUTE

PVD Thin Film Deposition

@ **University of Oxford**

The is a versatile research and development tool for thin film deposition under vacuum conditions. The medium size chamber offers additional space for more sources and optional deposition tools such as substrate heating and masking. The rectangular chamber design also offers additional pump configurations such as more powerful turbo molecular and cryo-pumps.

Specifications

MB-ProVap-5

Substrate: For substrates up to 100x100 mm or 150 mm wafers; Heated/cooled substrate holder from -30°C up to 100°C; Rotation up to 33 RPM

Ultimate vacuum: Down to: < 9 x 10-7 mbar

High-throughput UV/Vis

@ **University of Oxford**

The is a microplate/cuvette reader with accurate temperature control, microplate shaking and comprehensive data management with different detection modes:

UV-Visible Absorbance (Abs)

Fluorescence Intensity (FI)

Luminescence (Lum)

Time-Resolved Fluorescence (TRF)

Fluorescence Polarization (FP) .

Specifications

Spectramax M5

Plate formats 6, 12, 24, 48, 96, 384 wells

Light source Xenon Flash Lamp (1 joule/flash)

Detectors 2 photomultiplier tubes (PMT)

To book: www.royce.ac.uk

High-throughput DLS
@ University of Oxford

The DLS Platereader II is a high-throughput, automated, temperature-controlled Dynamic Light Scattering (DLS) analyser that allows for measurement of the size and interactions of nanoparticles and other macromolecules in situ in industry-standard microwell plates. No liquid handling occurs after dispensing into the plates – this maximizes throughput and minimises sample carryover.

Specifications

Support well plate formats: 96, 384 or 1536;
Size Range (Radius, Rh): 0.5 to 1000 nm

Minimum concentration @ 14 kDa: 0.125 mg/mL

Laser Wavelength: 830 nm

Laser Power Control: Programmable 10% – 100%

Attenuation Range: 1 to 106

Temperature Control: 4 – 85°C

Minimum sample volume: 4 μL

Impedance Analyser
@ University of Oxford

Impedance spectroscopy is a primary tool in materials research that helps characterise the physical properties and/or chemical interactions of the materials under investigation. The Bio-Logic MTZ-35 impedance analyser has the specifications and features required to address the broad scope of applications in the materials research field, for example a wide frequency range (10 μHz - 35 MHz) and superior accuracy (0.1% amplitude, 0.05% phase).

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Specifications

Measurement Ranges
- Inductance 10 nH to 10 kH
- Capacitance 1 pF to 1000 μF
- Resistance 1 mΩ to 500 MΩ
- Basic accuracy 0.1%

Output
- Output voltage 0 V to 5 V peak
- Output impedance 50 Ω
- Output resolution 50 μV to 5 mV level
- Output bias ±5 V

To book: www.royce.ac.uk

Air Sensitive XRD
@ **University of Oxford**

X-rays can be used to probe the repeating array of atoms that make up crystal structures; this is x-ray diffraction (XRD). Being a non-destructive technique it can be used on the most precious of samples with a high level of reproducibility. Often materials which are air sensitive are difficult to measure as windows are required to prevent exposure.

Specifications

Rigaku MiniFlex 600 sealed in a helium glove box which improves measurements dramatically.

X ray-tube: Cu

Focus size: 1mmx10mm, 0.4mmx8mm

High speed 1D detector , D/teX Ultra2 and 2D detector, HyPix-400 MF

Goniometer - Scan mode: 2θ/θ interlocking; radius: 150mm; 2θ Range of movement: -3θ θ +145°; Minimum step angle: 0.005°; DS continuously variable 0.625°, 1.25°; Solar Slit: 5°, 2.5°

Electrochemical Testing
@ **University of Oxford**

Battery testing typically requires a large number of simultaneous tests to be performed. The MPG-2 is a multi-channel, research grade battery cycler designed for research on intercalation compounds, batteries and supercapacitors.

The SP-150 is a full featured research grade potentiostat. With its modular chassis, this instrument can be customised to address all applications in the area of classical electrochemistry.

Capability

MPG-2

Compliance: -10; +10 V

Acquisition time: 200 μs

No limit in time and data recording

EIS measurement from 10 μHz to 20 kHz

SP-150

Compliance: 20 V range adjustable from [-20;0] V to [0;+20] V

EIS measurement from 10 μHz to 1 MHz

Acquisition time: 20 μs

To book: www.royce.ac.uk

Gas Chromatography
@ University of Oxford

Gas chromatography is a powerful tool for separating and analysing compounds that can be vapourised without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture.

Specifications

Detectors: DynaMax XR detection system

Electron Energy: adjustable from 0 to 150eV

Emission Current: Up to 350μA

Modes: Electron Impact Ionization (EI), with full scan (FS), SIM, and FS/SIM simultaneous within sample injection. Timed acquisition (t-SIM) mode

David Cockayne Centre for Electron Microscopy
@ University of Oxford

The centre houses a range of electron and ion beam instrumentation for materials characterisation and specimen preparation. These include transmission and scanning electron microscopy, analytical techniques and focused ion beam milling, nanofabrication and 3D analytical sectioning. A number of the instruments are optimised for characterisation of energy storage materials. Support scientists are available to assist with applications and user training.

Capability

JEOL ARM-200CF aberration corrected STEM with EELS, EDX and in-situ heating, liquid cell and vacuum transfer holders

Zeiss Crossbeam 540 analytical FIB-SEM with 3D EBSD and EDX

Zeiss Merlin FE-SEM with EDX optimised for low-Z materials and specimen vacuum transfer

Zeiss Merlin FE-SEM with high resolution EBSD/TKD

JEOL 2100 TEM with STEM and EDX

JEOL 3000F FEG-(S)TEM

Zeiss NVision FIB-SEM optimised for TEM and atom probe specimen preparation

Zeiss Auriga FIB-SEM optimised for nano / micro fabrication applications

To book: www.royce.ac.uk

Oxford Materials Characterisation Service

@ University of Oxford

OMCS provides industry with a diverse range of equipment and a team of experienced staff capable of solving or supporting their specific material characterisation requirements.

OMCS is a point of contact for those wishing to access facilities and expertise within Oxford University Department of Materials. We take a flexible approach to each client's needs, utilising our facilities and expertise to best suit the customer for example: Structural and compositional characterisation service; Consultancy; In-house training for customers on facilities; and Project partnership.

Capability

Optical microscopy

Molecular spectroscopy (UV/visible/NIR, FTIR, imaging Raman)

Profilometry (optical, contact stylus)

Scanning probe microscopy

Micro and nano mechanical measurements

Thermal analysis (TGA, H-DSC, calorimetry)

BET/BJH surface area and pore size distribution

Particle sizing and zeta potential measurements

Electron microscopy and microanalysis

Surface analysis (XPS)

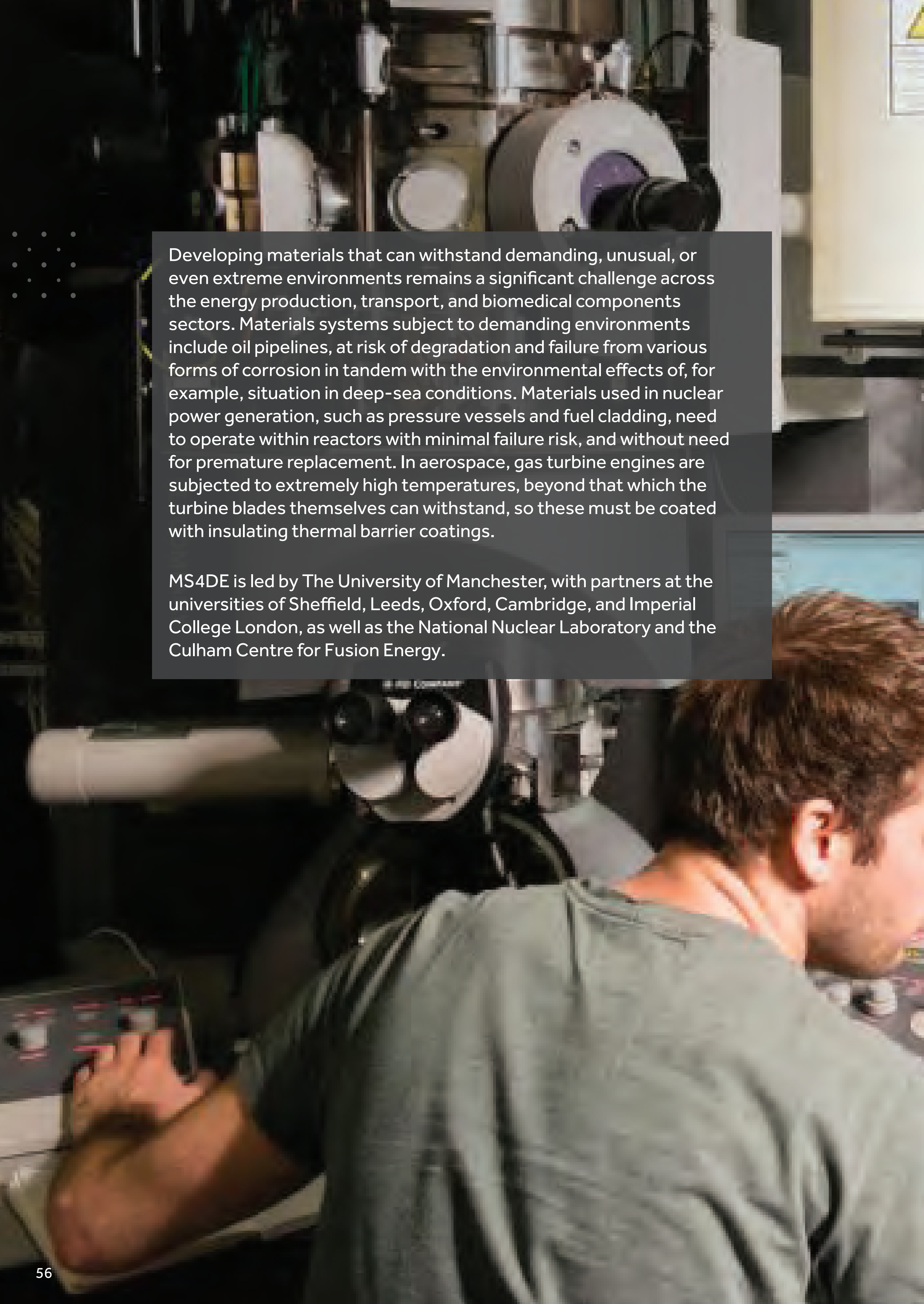
X-ray diffraction

X-ray fluorescence

Comprehensive range of sample preparation facilities, including wet/dry processing, FIB, etc.

To book: www.royce.ac.uk

To book: www.royce.ac.uk



Developing materials that can withstand demanding, unusual, or even extreme environments remains a significant challenge across the energy production, transport, and biomedical components sectors. Materials systems subject to demanding environments include oil pipelines, at risk of degradation and failure from various forms of corrosion in tandem with the environmental effects of, for example, situation in deep-sea conditions. Materials used in nuclear power generation, such as pressure vessels and fuel cladding, need to operate within reactors with minimal failure risk, and without need for premature replacement. In aerospace, gas turbine engines are subjected to extremely high temperatures, beyond that which the turbine blades themselves can withstand, so these must be coated with insulating thermal barrier coatings.

MS4DE is led by The University of Manchester, with partners at the universities of Sheffield, Leeds, Oxford, Cambridge, and Imperial College London, as well as the National Nuclear Laboratory and the Culham Centre for Fusion Energy.

MATERIAL SYSTEMS FOR DEMANDING ENVIRONMENTS

MANCHESTER 1824
The University of Manchester

HENRY ROYCE INSTITUTE

Material Systems for Demanding Environments

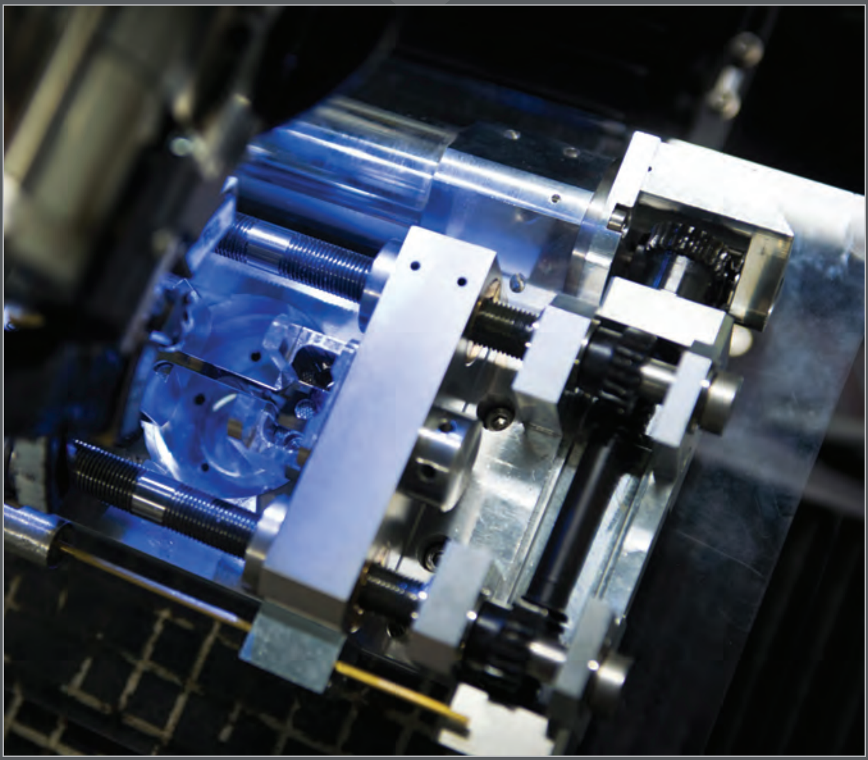
We will design, make, characterise and test new material systems for demanding environments, supporting energy, transport and other sectors. The theme will build upon existing research capabilities and strengths in areas such as coatings to enhance component performance, nuclear fuel cladding materials, hybrid multifunctional structural materials, and high-pressure high-temperature testing, including a large autoclave facility. The overriding aim is to develop materials solutions and systems that will enable a 'step-change' in component development for applications in aggressive environments. A crucial aspect of developing these new material 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, or the environmental impact of erosion-resistant coated piping with sensor capability, the economic and human impact of nuclear fuel assemblies could withstand accident scenarios for hours instead of minutes. Through the Royce collaboration these are all possibilities.

To book: www.royce.ac.uk

Demanding Environments Tribology Lab
@ **University of Manchester**

Bruker's UMT Tribolab marked the first installation in the Tribology lab at Manchester, with the machine now fully operational and ready for testing. The UMT Tribolab's capabilities are diverse, with many different modules available, allowing different mechanical and tribological test types to be performed using the same machine. Capability includes pin/ball-on-disk testing and reciprocating sliding tests on plate samples, at temperatures ranging from –25°C up to 1000°C, and it can further measure frictional parameters and the electrical contact resistance. Additionally, a tribocorrosion module is capable of investigating corrosion behaviour and wear simultaneously in selected electrolytes. The first tests utilising the Tribolab are now underway, looking at the wear of plasma electrolytically-treated aluminium alloys with different treatment depths, at temperatures ranging from room temperature to 300°C.

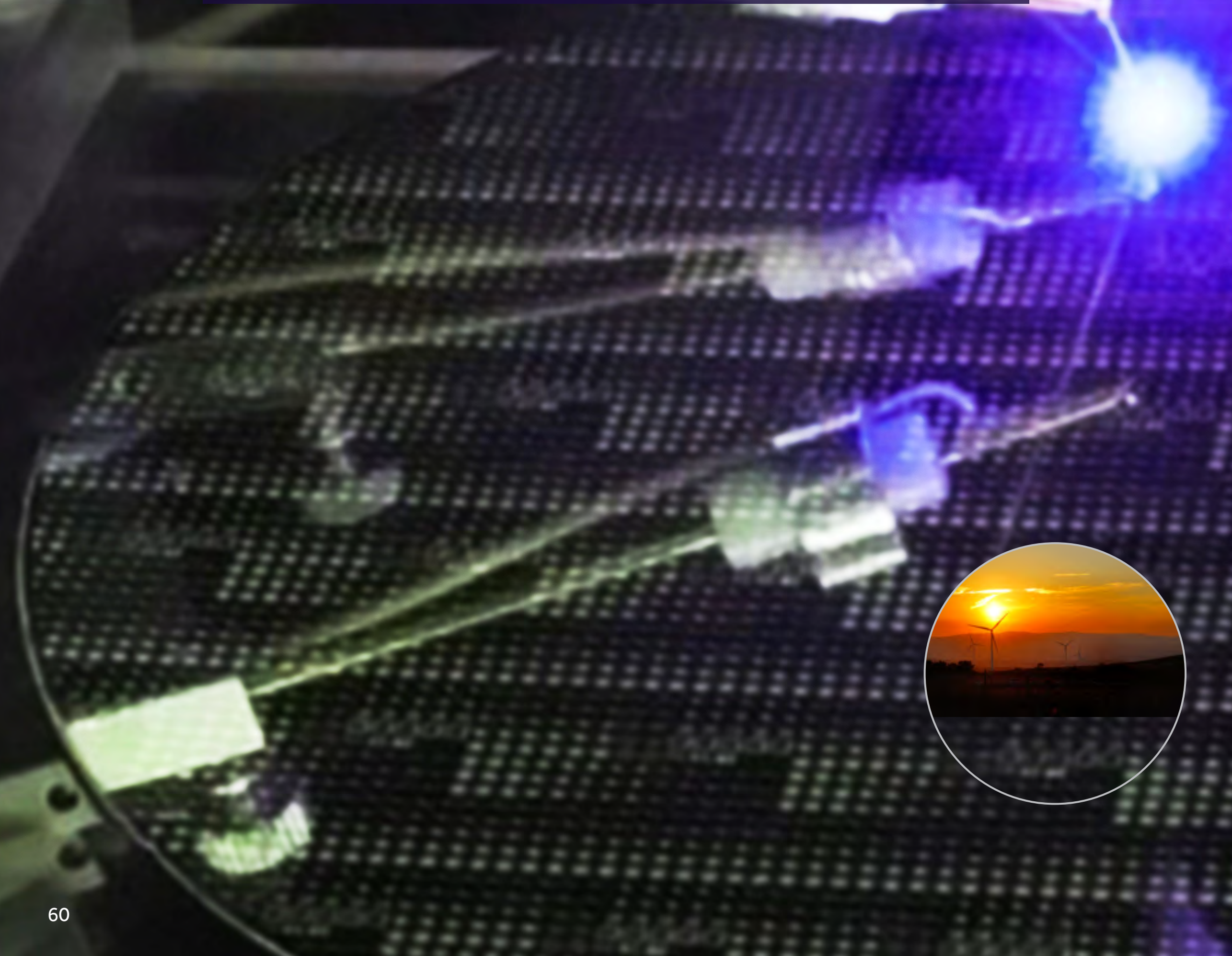
A range of further equipment for the evaluation of high-temperature coatings has been added to the suite, including a 'Dektak' stylus profilometer, a macro/micro scratch tester, and a 'Calotest' (ball craterer).



To book: www.royce.ac.uk

Today's excellent technologies operate at a level way below the scientific limits to performance. Energy Efficient ICT focuses on: Energy Generation, Energy Storage and Energy Use.

This area is led by Cambridge but will work closely with the Imperial/Leeds 'Atoms to Devices' core area, particularly in materials nanofabrication. Connections with the Oxford-led 'Energy Storage' core area are already established and there is a natural complementarity between large-scale storage in Oxford and the smaller-scale novel battery systems under study in Cambridge. 'Chemical Materials Design' led by Liverpool provides a natural link for the identification and development of very new functional materials systems. The Manchester-led '2D Materials' core area has excellent links with Cambridge through the Graphene Centres at both institutions.



MATERIALS FOR ENERGY EFFICIENT ICT

UNIVERSITY OF CAMBRIDGE

HENRY ROYCE INSTITUTE

Imagine a mobile phone which had: a processor and memory which drained 1/10th of the power; a safe battery with three times the energy density and ten times more charge; a transparent solar coating so that the battery could be recharged by the sun; a display with a quarter of the thickness, drawing third of the power and was unbreakable and half the weight that it is today. Your phone would need charging once a month and replacing once a decade. Royce can turn the possibilities above into reality. Energy Efficient ICT focuses on: Energy Generation: new materials that are able to power autonomous devices by harnessing energy from the environment. Energy Storage: significant improvements in the energy density, longevity, cost and compatibility of the various energy storage technologies required to power the next generation of ICT devices. Energy Use: radical approaches to reduce power consumption in processing and memory, towards the theoretical limits that are many orders of magnitude below current silicon-based technology, and making devices more lightweight.

Materials for Energy Efficient ICT
@ University of Cambridge

The Royce@Cambridge has been vital to attract further funding for energy materials research at the University of Cambridge. In January 2017 the EPSRC awarded £2.1 million networking grant funding to the Centre for Advanced Materials for Integrated Energy Systems (CAM-IES), a research network between Cambridge and four non-Royce partner universities. Cambridge is currently in the process of applying for research grants for the use of Royce@ Cambridge facilities for enabling essential research for prototyping and scale-up in the areas of hydrogen production, solid state and redox flow batteries for automotive and grid storage applications, energy harvesting for the Internet of Things, and solar cell technologies.

To book: www.royce.ac.uk

Wafer Scale AFM
@ University of Cambridge

The 8" Mapping Atomic Force Microscope is a high-resolution scanning probe microscopy system capable of accurately mapping material topography and device electrical properties at the nanoscale across a full 8" (200 mm) wafer without requiring any wafer rotation or manual position adjustment, thus allowing semi-automated morphology and performance sampling.

Specifications

Measurement of electrical properties in both processed and unprocessed devices: resistance, conductance, capacitance, local potential, piezoelectric response, magnetism and photoconductivity

PeakForce tunnelling atomic force microscopy allows measurement of electrical conductivity of delicate samples

Photoconductive atomic force microscopy allows study of photoconductive properties of photovoltaic materials

Energy Storage Test Equipment
@ University of Cambridge

An electrochemical quartz microbalance with Low Current Potentiostat tool provides the capability to characterise the changes in mechanical properties and mass of thin film materials during electrochemical cycling, chemical reactions or phase changes.

Specifications

Q-sense Explorer system with QE 401 electronics unit

Q-sense chamber platform a Q-sense flow module Q-sense electrochemistry module

Bio-Logic SP-200 potentiostat/galvanostat with Electrochemical Impedance Spectroscopy and Ultra Low Current mode

To book: www.royce.ac.uk

In situ Electron Microscopy
@ University of Cambridge

The in situ electron microscopy package comprises two dedicated TEM holders, a fast camera designed for in situ experiments and a holder storage unit where holders may be kept under vacuum. Using the holder the sample can be examined as part of a continuous flow experiment or, by using a static cell with electrical contacts, it is possible to image structural changes during electrochemical reactions.

Specifications

Protochips Poseidon continuous flow liquid cell in situ holder with additional electrochemical cell

Gatan double tilt vacuum transfer holder Model 648

Gatan OneView Camera Model that enables TEM images to be acquired at high frame rates (up to 300 fps). High quality video can be recorded over a range of resolution and speed combinations, from 4096 x 4096 pixels at 25 fps, to 512 x 512 pixels at 300 fps

Gatan turbo pumping station Model 655

3D X-ray Computer Tomography
@ University of Cambridge

The 3D CT microscope provides specialised 3D observation of microstructure evolution in materials at length scales on the order of 1 micron. It can perform in situ and 4D (time dependent) studies to understand the impact of simulated environments, provide non-destructive views into deeply buried microstructures, as well as compositional contrast for studying low Z or "near Z" elements and other difficult-to-discern materials.

Specifications

A particular emphasis is the development of specialised loading stages that will allow for accurate monitoring of 3D deformation processes (such as the swelling of a battery) during operation

To book: www.royce.ac.uk

UV Lithography Tool
@ University of Cambridge

The UV lithography tool allows patterning photoresists on silicon wafers. This is a key step in any lithographic process, and can be used to fabricate for instance MEMS energy harvesters or lithographically patterned electrodes for batteries or solar cells. This instrument enables silicon wafers to be patterned with feature sizes ranging from hundreds of microns down to 700 nm.

Specifications

4th generation Karl Suss MA6 tool allows to pattern features on Si wafers down to approximately 700 nm.

Alignment accuracy: 250 nm with video assist

Sample size: 10 × 10 mm samples up to 6" wafers

Exposure types: proximity, soft, hard, and vacuum

Optics: can be switched to either process thin or thick (e.g. SU8) photoresists and it features automatic wedge compensation.

Equipped with chucks to process pieces and 2, 3, 4, and 6" wafers and a range of mask holders

Electrical Characterisation Suite
@ University of Cambridge

The electrical characterisation suite consists of state-of-the-art equipment for high voltage and high frequency measurements. This suite allows accurate testing and characterisation of devices and materials in wafer, die or packaged forms, from -55 °C to +300 °C.

Specifications

Cascade Tesla 200 mm high voltage semiautomatic probe station

Keysight B1505A semiconductor parametric analyser/curve tracer

A number of stand-alone, high precision source measure units (SMUs)

High voltage capable Keysight 2 GHz oscilloscope

MGV Star lab antenna measurement system (650MHZ-18GHz)

Keysight N222A PNA network analyser (10 MHz to 26.5 GHz)

Keysight 65 GSa/s arbitrary waveform generator

Keysight Infiniium 20 GHz oscilloscope

Nanoscale Magnetic and Thermal Imaging System

@ **University of Cambridge**

The Nanoscale Magnetic and Thermal Imaging System uses atomic defects in nanoscale diamond crystals to probe the local temperature and magnetic field with a spatial resolution of ~10 nm. The technique is non-invasive and thus enables the characterisation of surface and interface effects in highly sensitive samples with nanoscale magnetic features.

Specifications

The dynamic range of the system spans DC to MHz with sub mT and mK resolution for the magnetic and temperature sensing modes, respectively

The imaging system is housed in a temperature-controlled and vibrationally isolated housing which enables <0.5 K temperature stability and <5 nm drifts over the course of several hours

Magnetic Property Measurement System

@ **University of Cambridge**

The Quantum Design cryogen-free Magnetic Property Measurement System (MPMS) is ideal if your research interests require detailed measurements of advanced functional magnetic materials, devices, and circuits, in which magnetic, electronic, optical and thermal properties are strongly coupled. The system enables detailed, long-duration, measurements and testing of magnetic phenomena.

Specifications

Operational temperature range 1.8 to 400 K

7 Tesla magnet

Modules for the application of multiple external fields, including magnetic, electric, mechanical, thermal, and optical

Magnetic moment sensitivity of better than 10-8 emu

To book: www.royce.ac.uk

Sputter Deposition and Nanoscale Patterning

@ University of Cambridge

The sputter deposition and nanoscale patterning suite enables in situ patterning and device fabrication. The suite provides a unique capability for 3D heterostructure fabrication which can generate novel magnetic and optical materials systems.

Specifications

AJA sputter deposition system for the automated growth of metallic heterostructures for devices

Zeiss Cross-beam 540 focused ion beam/ electron beam system

UHV Deposition System

@ University of Cambridge

The Ultra High Vacuum (UHV) deposition system comprises two interconnected UHV deposition chambers, an MBE system and a thermal/electron beam evaporator. The first chamber is for the epitaxial growth of topological insulators and related materials, and the second for the deposition of a range of metals.

Specifications

Flexible Molecular beam epitaxy (MBE) system for well-controlled growth of high-purity epitaxial layers and heterostructures

After growth in this chamber, samples can be transferred under contamination-free UHV conditions to the evaporator for deposition of capping layers

The UHV evaporator chamber has several different sources using both thermal and electron beam evaporation techniques to deposit a range of metals onto samples transferred from the MBE system

To book: www.royce.ac.uk

Ambient Processing Cluster Tool

@ **University of Cambridge**

The ambient processing cluster tool is a custom-built tool that integrates different vacuum as well as liquid-based deposition technologies for a wide range of functional materials into a common inert glove box atmosphere. The tool gives access to a wide range of functional materials, including transition metal oxides for battery and other applications, organic and hybrid organic-inorganic semiconductors, two-dimensional materials, polymer composites etc.

Specifications

Ten glove box modules interconnected by a semi-automated inert atmosphere transfer system

Thermal evaporation

Sputtering

Pulsed laser deposition (PLD)

Chemical vapour deposition (CVD)

Atomic layer deposition (ALD)

Aerosol printing, screen printing and slot-die coating

Modules for metrology, thin film encapsulation and packaging

Environmental XPS

@ **University of Cambridge**

The near ambient pressure (NAP) X-ray photoemission spectroscopy (XPS) system is for high-throughput chemical surface analysis under application relevant environmental conditions. The system overcomes barriers of traditional XPS systems by enabling analyses at a wide range of atmospheres ranging from 10-7 mbar up to 100 mbar.

The system will be run together with an existing UHV-based XPS/UPS system.

Specifications

SPECS XR 50 MF X-ray Source

μ-FOCUS 600 X-ray monochromator

Differentially pumped PHOIBOS 150 1D-DLD NAP analyser

Sample holder with built-in laser heating

Allows direct probing of samples at temperatures up to 1000 °C in these atmospheres

Scannable focused extractor type ion source for depth profiling

To book: www.royce.ac.uk

Electron-beam Lithography System
@ University of Cambridge

The Electron-beam Lithography System can be used for flexible configuration to fit application requirements and is an essential manufacturing tool for fabrication of deep nanoscale devices. It allows both the cutting edge fabrication of small scale (lab level) devices and expanding these capabilities towards a large scale production, thus bridging university research activities to wafer scale manufacturing processes.

Specifications

RAITH - EBPG 5200 thermal lithography tool

Field emission gun for operation at 100 kV

High kV mode for high aspect ratio nanostructures

Automated high speed direct write

Fastest Gaussian Beam system on the market

Fast, arbitrary shape 100 MHz pattern generator

Can process 8" wafers and 7" masks with minimum feature size <8 nm

Precise overlay of features size <10 nm

Fastest tool on the market for "high density" patterns

Wide Bore Magnet
@ University of Cambridge

This magnet system will facilitate developments in processing of mesoscopically ordered materials, superconductors and low loss high permeability materials. While the system is provided with a generic fixed sample probe and a 100 A transport probe, our technical staff can exploit the large internal bore of this magnet by designing custom measurement probes. This magnet can facilitate materials characterisation and process development across the full range of Royce areas.

Specifications

Oxford Innovative Cryogenic Engineering

12T solenoid fitted with a VTI with a 100mm usable bore

Temperature control from 325 K to <2 K field

Homogeneity of 0.05 % over a 1 cm DSV and 0.5 % over a 4 cm DSV

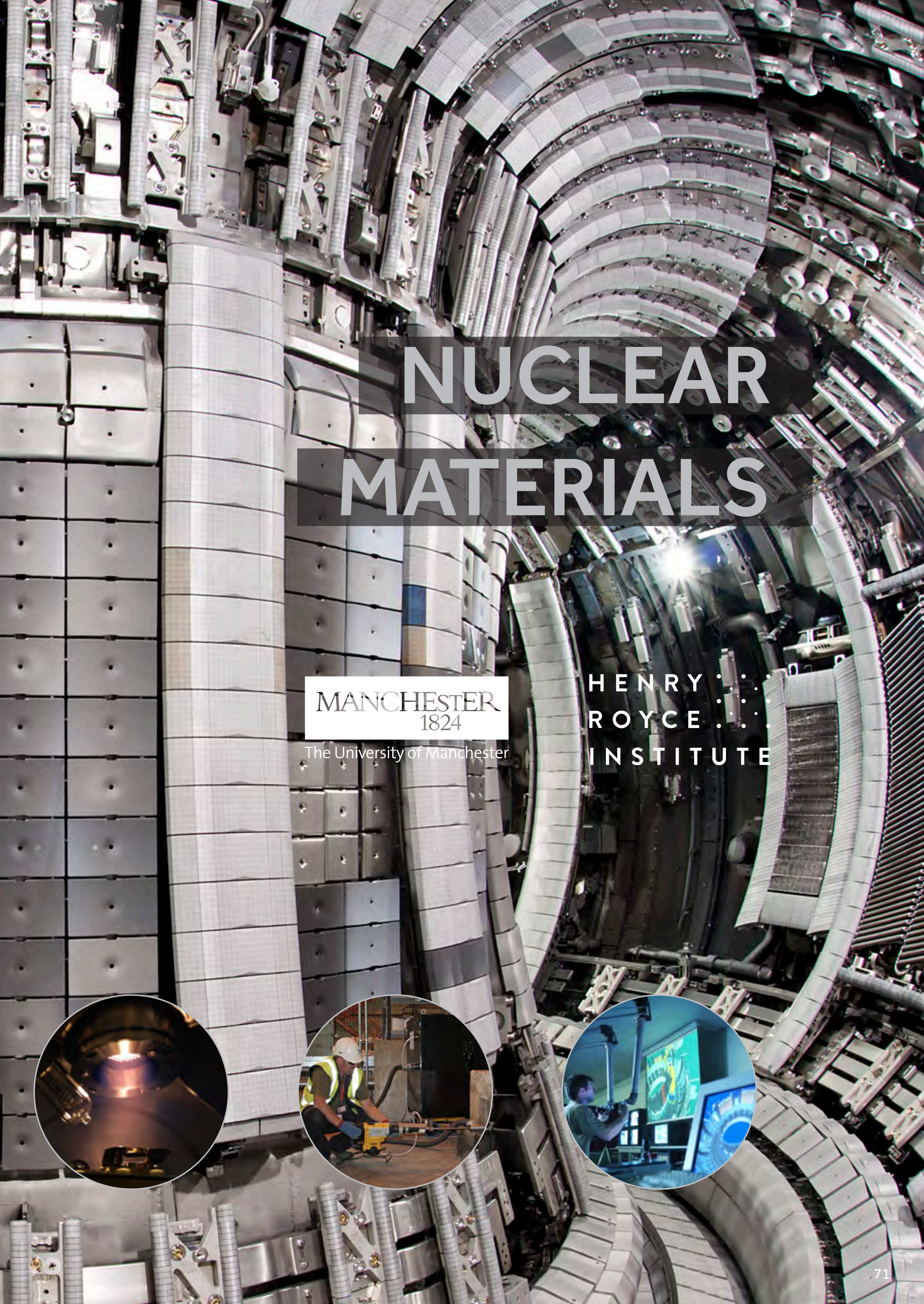
Cryo-cooler operated with a He gas filled cooling loop

VTI will operate in static, dynamic and one-shot modes

To book: www.royce.ac.uk

The research programme will be structured around three research themes- *The Lifecycle of Fuels and Nuclear Materials* (e.g. spent fuel management, Pu management, future reactor fuels); *Structural Materials for Future Nuclear Energy Systems* (e.g. materials to withstand high heat loads, high radiation fields, aggressive coolants); and *Material Performance in Nuclear Energy Systems* (e.g. evolution of nuclear materials and their containers, and of nuclear plant; new ways of monitoring condition and predicting/identifying failure).

This research theme brings together university expertise from The Universities of Manchester and Sheffield, and specialist centres NNL and UKAEA. Activity will also take place at Oxford and Imperial College London.



NUCLEAR MATERIALS

MANCHESTER 1824
The University of Manchester

HENRY ROYCE INSTITUTE

Nuclear Materials @ **The University of Manchester**

Expansion of capabilities in Manchester will be associated with the development of the Royce hub building in which nuclear facilities will include laboratories for the preparation and characterisation of irradiated materials, including carbonaceous materials and nuclear fuels.

Carbon-based materials processing equipment; thorium, uranium and plutonium fuels synthesis equipment; spark plasma sintering; electron optics (scanning and transmission electron microscopes, electron probe, X-ray photoelectron spectroscopy); corrosion and autoclave facilities

Nuclear Materials @ **NNL**

NNL will provide a range of facilities that support innovative materials research from 2018. These will include:

- An Atomic Resolution Electron Microscope (JEOL ARM200CF) with an Electron Energy Loss Spectrometer (Quantum 965ER from Gatan);
- Hot Cell Optical Microscope with Laser Raman Spectroscopy and Microhardness;
- Plasma FIB for micro or nano-scale machining to produce site-specific samples for subsequent microstructural analysis. The P-FIB will also operate as a high quality SEM and enable SIMS analyses of active materials;
- Glovebox Raman which will provide molecular information through interrogation of bond vibrations. This will form a part of an overall characterisation suite of techniques (e.g. microscopy, EDX, ICPMS, radiometrics).

To book: www.royce.ac.uk

Radiation damage to materials @ **Dalton Cumbrian Facility**

The ion accelerator systems and high dose rate cobalt-60 gamma irradiator at the Dalton Cumbrian Facility provide the opportunity to carry out world-leading research that can advance our detailed understanding of the effects of ionising radiation on a wide range of metallic and non-metallic materials. The accelerators can deliver a comprehensive range of ions at a wide range of energies and fluences and, like the gamma irradiator, are specifically designed to support a wide range of in-situ and ex-situ experimental techniques. In addition, a range of high-end material preparation and characterisation equipment is also available at the facility.

Capability

5MV tandem ion accelerator:

High current TORVIS ion source providing 10 MeV $^{1}H^{+}$ at up to 100 μamps, 15 MeV $^{4}He^{2+}$ at up to 15 μamps

Low current SNICS ion source providing partially and fully stripped heavy ions, 35 MeV typically up to 1 μamp

2.5 MV single-ended accelerator:

Light ion accelerator providing 2.5 MeV 1H+ at up to 100 μamps and 2.5 MeV $^{4}He^{1+}$ at up to 50 μamps, plus other gas ions (e.g. Kr, Xe) on request

Cobalt-60 gamma irradiator:

Absorbed dose rates of >20 kGy/hr to <100 Gy/hr,

9 litre sample chamber incorporating three turntables & two 19mm access ports for connection to external experimental rigs

To book: www.royce.ac.uk

Microstructural Characterisation suite for Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has a range of instruments capable of providing high resolution imaging of samples as well as obtaining topographical, crystallographic and chemical information.

The dual beam FIB allows for machining test samples on the microscale to probe site specific mechanical properties and lift out microscopic samples for (S) TEM and Atom Probe Tomography characterisation.

Capability

FEG-SEM: Tescan Mira XH 3

EDS/EDX: Oxford Instruments X-Max 80

EBSD: Oxford Instruments NordlysNano

Dual Beam FIB: FEI Helios NanoLab 600i

AFM: Veeco D3100 with Nanoscope IV controller

PMI XRF: Olympus Delta premium

Thermo-physical Characterisation suite for Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has a suite of instruments enabling the assessment of the material properties as a function of temperature, adapted to work on irradiated materials. This includes: specific heat capacity, thermal diffusivity, thermal conducitivity, thermal expansion and specific heat capacity.

Capability

Laser Flash Analysis: Linseis LFA 1000, -125°C to 2000°C

Dilatometer: Linseis L75V, -125°C to 2000°C

Simultaneous Thermal Analysis: Linseis STA PT1600 (TGA-DSC): -125°C to 1600°C

To book: www.royce.ac.uk

Hot-cell Line and Shielded Rooms for Processing and Analysis of Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has the capability to process and carry out analysis on neutron irradiated materials in a line of hot-cells (3.75TBq). Samples are processed by trained technicians using master-slave manipulators.

In 2018 all scientific testing equipment described below will be integrated into shielded research rooms to allow use of radioactive samples (3.75GBq).

Capability

Hot-cell equipment:

Buehler minimet for grinding and polishing

Slow cut saw

Shear metal cutter

TEM disc puncher

Mounting: Struers hot-press, cold-set resin mounting, crystal bond

Gamma spectroscopy KROMEK GR1

Optical microscopy

Weighing balance

Labscale spark erosion cutting

Sample Preparation for Non-Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has a fully equipped sample preparation laboratory that houses a series of equipment to prepare metals and ceramics for further analysis. The finest possible finish allows, for example, Electron Backscattered Diffraction (EBSD) analysis or strain analysis on fatigue samples.

Equipment from the hot-cell line is replicated here to allow for methodology development and verification on unirradiated samples before processing in the hot-cell.

Capability

Cutting: Buehler IsoMet high Speed Pro, Struers Minitom, labscale spark erosion

Hot-mounting press: Buehler SimpliMet 4000

Grinding & polishing: Buehler EcoMet Pro, Buehler MiniMet, Buehler VibroMet 2 7

Sputter coater (Au/Pt/C/etc): Quorum Technology Q150T ES

Shear metal cutter

TEM disc puncher

Optical microscope: Olympus BX15M

Dimple Grinder: Gatan DG II

Ion Polishing: Gatan PIPS II

Electro polishing: Buehler PoliMat 2, Metalthin twinjet polisher

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Mechanical Testing suite for Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has instruments capable of determining mechanical properties of irradiated materials. Nanoindentation allows for determination of hardness, elastic modulus, yield stress, true stress vs true strain behaviour.

Various load frames can be used for tension, compression, bending, fatigue, dynamic characterisation, creep, stress relaxation and accelerated lifetime testing.

Capability

Nanoindenter: Keysight G200 with NanoVision Stage and XP Indentation head

Dynamic Fatigue load frame, TA Electroforce 3500, 15 kN, 50 Hz

Static Load Frame: Shimadzu AGS-x, 15 kN

In-situ SEM Load Frame: Deben Mtest 5000, 5 kN, clamp heating up to 600°C, in-situ EBSD

Gas Absorption and Desorption for Radioactive Materials @ **UKAEA-MRF**

UKAEA-MRF has the capability to investigate the interaction of gases with sample surfaces.

Thermal Desorption Spectroscopy allows for measuring the desorption rates for gases on irradiated samples.

The custom built Gas Impregnation Technique allows sample exposure to well controlled plasmas of accelerated ions to impregnate the sample with known amounts of specific gases.

Capability

Thermal Desorption Spectroscopy: Hiden-Analytical HAL/3F RC 1051-9 PIC mass spectrometer

Gas Impregnation Technique, 500eV, <500°C, Tritium, D_2, He, Ar, N_2, Air

To book: www.royce.ac.uk

Nuclear Materials @ **UKAEA-MRF**

UKAEA-MRF will provide additional capability to analyse irradiated materials in 2018. Mechanical testing upgrades of existing load frames are planned to allow for testing at temperatures up to 800°C. A set-up for ultrasonic fatigue testing on mesoscopic samples is in development with Oxford.

Further physical characterisation techniques like Gas Pycnometry (density) and Impulse Excitation Testing (elastic properties) will be obtained and integrated in the hot-cell line.

The microstructural characterisation suite will be considerably extended with a Confocal Laser Scanning Microscope with integrated Raman spectroscopy, an X-ray Diffraction goniometer and a Wavelength Dispersive Spectroscopy detector for the SEM.

Furthermore additional shielded rooms for scientific equipment and provisions for remote sample mounting will be installed in addition to glovebox capacity for low activity sample preparation.

To book: www.royce.ac.uk

Materials characterisation is an essential underpinning capability and applicable to research across all the Royce nine themes. There are several techniques capable of providing 3D information, either non-destructively or destructively rely on penetrating beams such as X-rays, whereas destructive methods involve progressive material removal and can range from large scale mechanical serial sectioning down to the removal of atoms atom by atom, as in atom probe microscopy. Conventionally, information has been brought together from different samples at different scales statistically to build up a multi-scale picture (e.g. hierarchical pore structures).

Each of the Royce partners has materials characterisation capability accompanied by dedicated staff with experience relating to each of the themes. The University of Manchester has an emphasis on coupling non-destructive (3D+time) X-ray tomography with destructive (3D) electron tomography with the purpose of identifying the key information that controls performance. Termed correlative tomography this approach can provide a much richer, multi-faceted, hierarchical picture of materials behaviour under a range of conditions.

MATERIALS CHARACTERISATION

MANCHESTER 1824

The University of Manchester

HENRY ROYCE INSTITUTE

Multidisciplinary Characterisation Facility (MCF)

@ **The University of Manchester**

This world-leading facility connects imaging and characterisation techniques across multiple length scales (component to sub-nm) to gain an understanding of advanced materials. A speciality is moving between modalities to forensically investigate materials structure and failure mechanisms.

The MCF brings together technical teams from Henry Moseley X-ray Imaging Facility, Electron Microscopy Centre and Surface Science to provide this integrated imaging and characterisation capability.

Our extensive suite of state-of-the-art equipment allows both our industrial and academic clients the means to study materials as close as possible to those experienced in service to identify the key information that controls performance.

Henry Moseley X-ray Imaging Facility

@ **The University of Manchester**

This facility hosts 10 X-ray CT systems and equipment for time-lapse in-situ imaging of samples under tension, torsion, compression and temperature. We can accommodate a wide range of sample sizes up to 1m in our walk-in bays as well as detect features as small as 50nm with our ultra-high resolution instrument. Users also have access to our suite of high-power data visualisation and analysis computers to process their data.

Capability

- ZEISS Versa 520
- ZEISS Versa 520 with DCT
- ZEISS Ultra 810
- Nikon Xtek XTH-225
- Nikon Xtek 320/225 KV bay
- Nikon Xtek High Flux bay
- Rapiscan RTT110
- Spectroscopic Imaging and Tomography bay

To book: www.royce.ac.uk

Electron Microscopy Centre
@ The University of Manchester

A range of instruments capable of providing high resolution imaging of samples with the capability to collect topographic, chemical, phase, and crystallographic orientation information. Several pieces of the equipment have the capability to gather this information in both 2D and 3D. The dedicated support team has expertise on a wide range of materials.

Capability

FEI Titan G2 80-200 S/TEM ChemiSTEM

TALOS F200X TEM with wet stage

FEI HELIOS Plasma FIB with Oxford EBSD & EDS

FEI HELIOS 660i FIB with Oxford EBSD & EDS

FEI Quanta 3D FIB

JEOL JXA-8530F Electron Microprobe

ZEISS MERLIN FEG-SEM with Oxford EBSD & EDS

ZEISS SIGMA FEG-SEM with Oxford EBSD & EDS

Quanta 250 SEM with 3D EDS 3View system

Surface Science
@ The University of Manchester

Our surface science equipment is capable of investigating the mechanical behaviour of surfaces and the molecular and isotopic chemistry of materials from surface to bulk.

The range of equipment can provide information on mechanical properties of surfaces, their atomic and molecular structures as well as trace element and isotopic mapping at nanoscale resolution.

Capability

CAMECA NanoSIMS 50L
Laser Scanning Confocal Microscope
Near Ambient Pressure X-ray Photoelectron Spectroscopy (NAP-XPS)
Horiba T64000 Triple Stage Raman Spectrometer
Horiba LabRAM Evolution HR Raman Spectrometer
Anasys NanoIR AFM
Multimode8 AFM
MTS XP Nanoindenter
Hysitron Bioindenter
Hysitron Ti950 Triboindenter with Xsol Heating Stage
Hysitron Pi85/87 Picoindenter

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