

# Driving the Electric Revolution Industrialisation Centres

### Growing UK Manufacturing in Power Electronics, Machines and Drives

Backed by UK Government funding, Driving the Electric Revolution Industrialisation Centres (DER-IC) reduce the cost and risk of manufacturing Power Electronics, Machines and Drives (PEMD) in the UK by providing open access to expertise and state-of-the-art manufacturing, test and validation equipment.

DER-IC supports the PEMD supply chain with

- access to supply chain partners
- specialist capability
- · design for manufacture
- manufacturing process development and scale-up
- open-access capital equipment
- prototyping
- testing
- training

#### For further information, contact

info@der-ic.org.uk www.der-ic.org.uk



# **About DER-IC**

PEMD forms the foundation of critical control and motion technologies across all sectors. From aerospace, to automotive, bulk electrical power transfer, consumer electronics, heating and lighting, marine, off-highway, rail, renewable energy and robotics, PEMD plays a vital enabling role.

Driving the Electric Revolution Industrialisation Centres (DER-IC) are a UK-wide network of over 30 Universities and Research and Technology Organisations (RTO). Each network partner brings expertise, specialist knowledge and capability. Leveraging the collective strength of the partner network, DER-IC's mission is to work with industry to grow UK PEMD manufacturing capability, capacity, and competitiveness.

### **Funded by DER**

The funding was provided through UK Research and Innovation's Challenge Fund delivered by Innovate UK. Part of this investment established the UK-wide DER-IC network, led by Newcastle University and operating from regional centres in the North East, the Midlands, the South West and Wales, and Scotland.

# Supporting Skills Development

DER-IC collaborates with the Electric Revolution Skills Hub which provides inclusive access to specialised training and employment across the UK. The Electric Revolution Skills Hub also delivers a community led project - driving a common language for the skills and competencies in electrification for industries for whom it is essential. To find out more visit www.electricrevolutionskillshub.co.uk







# **How DER-IC Can Help**

### **Working with DER-IC**

The entire DER-IC network can be accessed through any of the regional centres.

### **How to Engage**

The DER-IC network

- engages in collaborative research and development projects (CR&D) funded through UKRI, Innovate UK, regional initiatives and other funding schemes
- · can deliver projects and access to equipment and capability through commercial contracts
- provides SME advice and regional support programmes
- hosts an online portal enabling partners to highlight PEMD capability, and link with the national DER-IC network and industry to promote business to business collaboration

### **Benefits of Engagement**

DER-IC can facilitate targeted introductions to expedite access to the most relevant researchers, engineers and capability across the partner network. Company IP can be protected through all engagement routes.

By using DER-IC equipment and capability, supply chain partners can

- develop and verify manufacturing process and product performance ahead of committing to capital investment
- · reduce cost and risk of new product introduction (NPI)
- · achieve a faster time to market

# Capabilities

# **Thematic Groups**

Product and Manufacturing Process Equipment Design

Manufacturing Process Development and Optimisation

Prototype Manufacture and Scale-up Support

In-Process and End-of-Line Test and Validation

Material and Component Characterisation

Electrification Skills Learning and Development





Driving the Electric Revolution

# **The National Network**

- 1 University of Birmingham
- 2 University of Bristol
- 3 Centre for Process Innovation (CPI)
- 4 Compound Semiconductor
  Applications Catapult
- 5 Coventry University
- 6 CSconnected
- 7 DER-IC North East
- 8 University of Edinburgh
- 9 University of Glasgow
- 10 Loughborough University
- 11) University of Manchester
- Manufacturing Technology
  Centre (MTC)
- Michelin Scotland
  Innovation Parc (MSIP)
- National Composites
  Centre (NCC)
- National Manufacturing
  Institute Scotland (NMIS)
- National Physical Laboratory (NPL)

- Newcastle University
- (18) Northumbria University
- University of Nottingham
- Nuclear Advanced

  Manufacturing Research

  Centre (NAMRC)
- 21 Offshore Renewable Energy (ORE) Catapult
- PNDC PNDC
- The University of Sheffield
- University of Sheffield Advanced Manufacturing
  Research Centre (AMRC)
- (25) University of Southampton
- University of St Andrews
- University of Strathclyde
- (28) Swansea University
- 29 Teesside University
- (30) University College London (UCL)
- The Welding Institute (TWI)
- 32) The University of Warwick
- WMG at The University of Warwick



# **DER Funded Equipment**

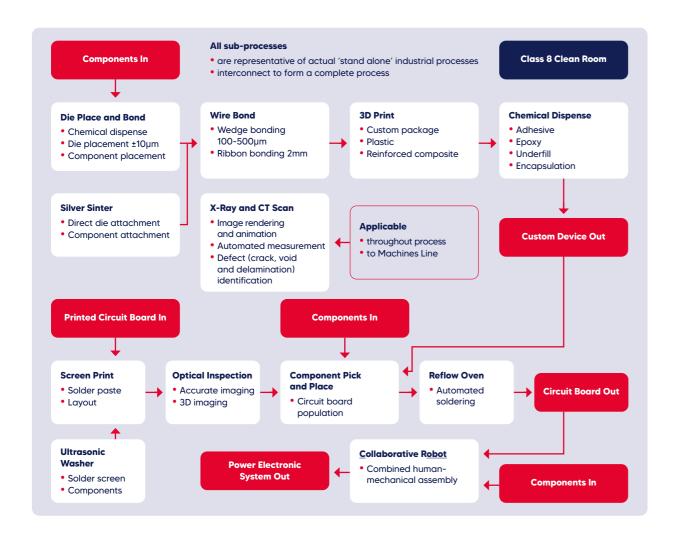
### Driving the Electric Revolution Industrialisation Centre North East

### ODER-IC North East

DER-IC North East is part of Newcastle University and is located near the International Advanced Manufacturing Park, Sunderland, the heart of the region's advanced manufacturing base. The Centre is equipped with DER-funded Power Electronics and Electrical Machines assembly lines. Individual processes are representative of mid to high volume manufacturing, are highly reconfigurable, and incorporate in-process inspection to enable process development, optimisation, and verification. Assembly is supported by dynamometer, X-ray and CT scan, and environmental test equipment.

#### **POWER ELECTRONICS ASSEMBLY LINE**

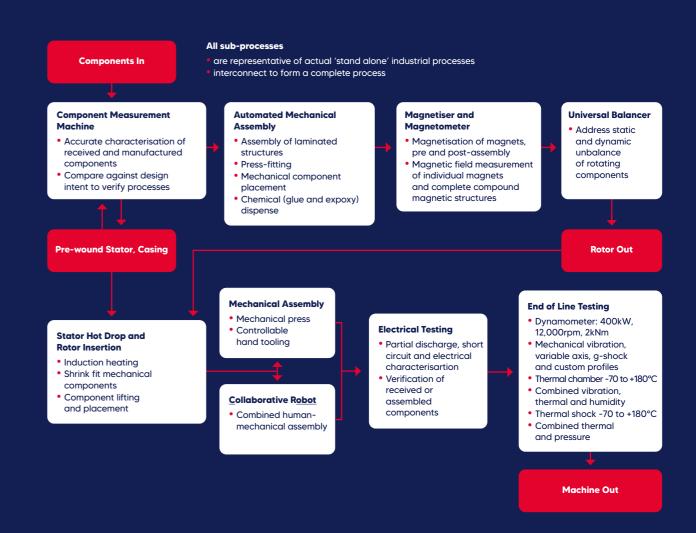
Located within a cleanroom environment, state-of-the-art, flexible, industry-representative equipment enables custom packaging of semiconductor die, devices and integrated circuitry, and surface mount circuit board manufacture and inspection, providing a platform for the development and scale-up of advanced manufacturing processes for highly integrated power electronic systems. Specialist inspection and diagnostic equipment enables verification of manufacturing process quality.





#### **ELECTRICAL MACHINES ASSEMBLY LINE**

The Electrical Machines assembly line includes a range of flexible, automated assembly, and test and measurement equipment, providing an end-to-end platform for electrical machine manufacturing process development.



# Driving the Electric Revolution Industrialisation Centre Midlands

### The University of Nottingham

The University of Nottingham received funding for new equipment from DER that is housed at the Power Electronics and Machines Centre (PEMC). The PEMC offers purpose-built laboratories for the Power Electronics, Machines and Control Research Group, the largest such group of researchers in the world, and sits at the heart of the University's commitment to establishing Nottingham and the East Midlands as a hub for the translation of net zero technologies from research bench to real world solutions.

#### HIGH FREQUENCY COIL MANUFACTURING AND MAGNETIC TEST AND CHARACTERISATION

DER has enabled funding for developing a "Future Factory for High Performance Electrical Machines" – a facility for developing manufacturing processes for high performance electrical machines through a number of winding machines including:

- Litz wire winding process
- Advanced hairpin solutions for high frequency drives
- · Fully customisable vacuum pressure impregnation (VPI) and a range of magnetic and insulation test equipment





### The University of Warwick

The University's DER-funded equipment is located within the School of Engineering and comprises a power electronics module assembly, reliability and failure analysis facility. The equipment is focused on enhancing the reliability of wide band gap power electronics modules and allows the technology for reducing size, weight and cost across all sectors to be better understood for volume production.

#### **POWER ELECTRONICS RELIABILITY AND FAILURE ANALYSIS FACILITY**

- Scanning acoustic microscope
- Environmental chamber for reliability testing
- Industrial data logging equipment / HIL
- De-capsulation facility
- Power cycling facility
- Fiber Bragg grating system
- Thermal camera

#### 3 WMG

WMG is an academic department at The University of Warwick and the leading international role model for successful collaboration between academia and the public and private sectors. The funding from DER, additionally supported by the High Value Manufacturing Catapult, has established a Winding Centre of Excellence, providing capability for UK based OEMs and SMEs to develop eMachine solutions.

#### WINDING CENTRE OF EXCELLENCE

Equipped to manufacture all types of windings at production quality, specialising in hairpin stators:

- Discrete hairpin winding and continuous hairpin winding
- Distributed winding and winding of synchronous wound rotors
- Concentrated windings for radial and axial flux machines
- Laser welding for busbars and connections
- Insertion robot for magnetised and unmagnetised magnets for rotor assembly
- Magnetiser, rotor assembly to hub, trickle impregnation, stator loading into housing and curing ovens
- In-process testing of electrical, thermal and mechanical effects





### Driving the Electric Revolution Industrialisation Centre South West and Wales

### University of Birmingham

The University of Birmingham's DER funding has been used to construct a production line for recycled sintered magnets with an 'end-to-end' supply chain to enable a UK supply of recycled rare earth magnets from processed oxides. Currently, there is no capacity for sintered magnet manufacturing in the UK, and this equipment provides a platform to secure a strategic supply of NdFeB alloy powder which can be fed into any part of the value chain from chemical processing to alloy production, or directly into magnet manufacture.

#### **RECYCLED SINTERED MAGNETS PRODUCTION LINE**

Large scale recycling and production facility for Rare Earth Permanent Magnets (REPM)

A range of advanced and highly unique equipment to enable the sensing, sorting, separation, purification
and re-processing of rare earth permanent magnets (REPM). This includes pre-processing equipment
(cropping machines), a 2000 litre capacity hydrogen reactor, a powder processing unit including sieves, jet
mill and blending system, uniaxial and transverse magnetic aligning presses, a pellet press and a sintering
furnace. The equipment can also be used to process primary rare earth cast alloys.

Machining and finishing

 A range of machining and finishing equipment for REPMs including electrical discharge machining (EDM) and grinding equipment.

Characterisation facilities for magnetic materials

• This includes 2 permeameters running up to 200°C, 2 vibrating sample magnetometers (VSM) to measure the hysteresis loops of solid and powdered magnetic samples, particle size analysis, 3D magnetic scanning, Kerr effect microscopy and inductive coupled plasma (ICP) chemical analysis equipment.

Bench scale magnet processing equipment

• This includes high velocity ball mills, glove boxes, a pulse magnetiser, isostatic presses and sintering furnaces for sample sizes between 10-50 grams.

### **CSA Catapult**

The CSA Catapult in Newport, Wales, is a recipient of DER-funded equipment, with a focus on materials and components. The new equipment will address supply chain challenges with high power density and high temperature device packaging.

### COMPOUND SEMICONDUCTOR APPLICATIONS (CSA) CATAPULT ADVANCED PACKAGING PROTOTYPE FACILITY

Ceramic 3D printing for device packaging:

- Ceramic 3D printer
- Thermal optimisation
- · Ceramic debinder furnace
  - ceramic post process
- · Ceramic oxide oven
- post process
- · Ceramic sintering furnace
- high temperature ceramics
- · Cleaning station

#### Metal 3D printing:

- Metal 3D printer (e.g. Copper)
- Printing materials supply
- Metal debinding oven
- debinding process for package
- Metal sintering oven
  - sintering process

#### Metrology and processing tools:

- Tensile testing equipment
  - device quality check
- · Fully automated Vickers micro hardness tester
  - device quality check
- Laser cutting / drilling machine
  - device processing for novel package design
- · Lapping and polishing machine
  - device polish / lapping for preparation
- Density / volume measurement for 3D object





### Swansea University

Swansea University's Centre for Integrative Semiconductor Materials (CISM) has received a £5M investment from DER to create a wide band gap power electronics component industrial pilot line. The pilot line is also part of CSconnected, the world's first compound semiconductor cluster based in South Wales. The new equipment is housed in CISM at Swansea University's Bay Campus in bespoke ISO 5 and 6 Cleanrooms.

#### WIDE BANDGAP POWER ELECTRONICS COMPONENT INDUSTRIAL PILOT LINE

The pilot line will include:

- Advanced lithography photo and nano-imprint
- Advanced etch synapse deep dry etch
- Advanced deposition dielectric and metal
- Backend rapid thermal and laser anneal, wafer dice and grind



### Driving the Electric Revolution Industrialisation Centre Scotland

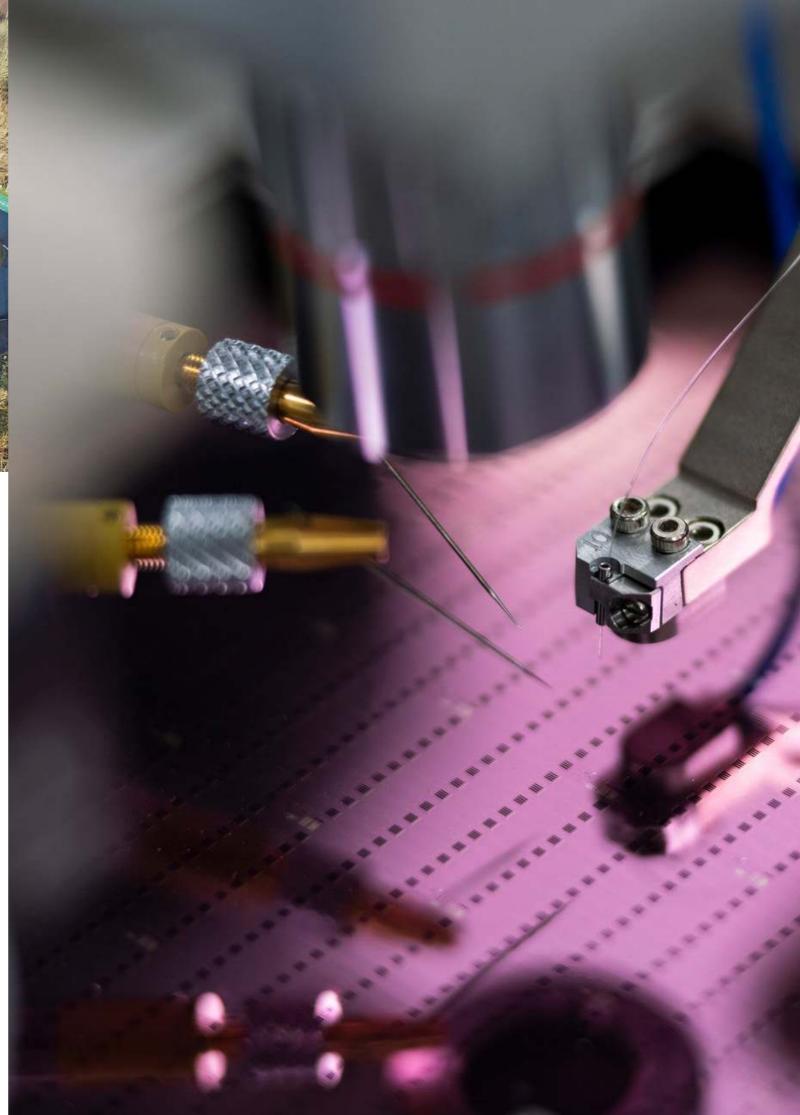


DER-IC Scotland's new equipment is being housed at PNDC (University of Strathclyde). PNDC specialises in de-risking and accelerating the commercialisation of innovative MW scale technologies and architectures through testing and validation using real-world hardware and simulation capabilities. It has a proven track record in innovation and supporting the advancement of novel technologies through design, manufacture and verification at system, sub-system and component levels. PNDC works with a broad range of stakeholders across industry, academia and policy making.

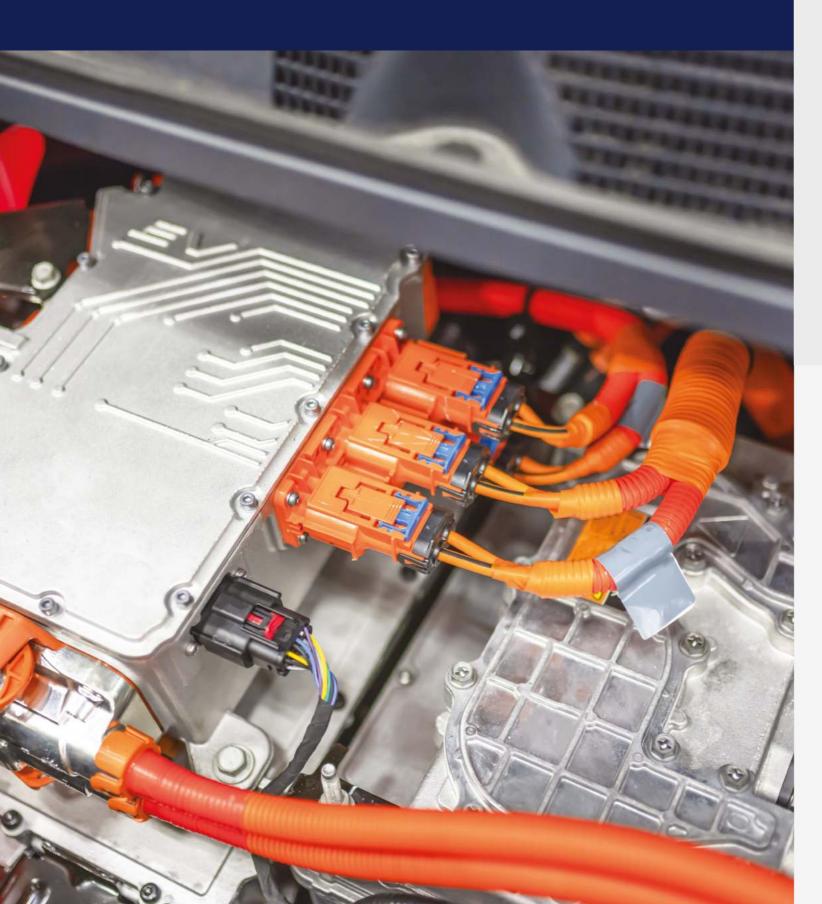
#### HIGH-POWER PROPULSION AND POWERTRAIN SYSTEMS VALIDATION CAPABILITY

MW-scale innovation and testing capability, comprising:

- MW rated dynamometers 2 units of 1 MW power rating each, switchable torque / speed ranges, comprehensive data acquisition capability to enable testing of powertrains for Aviation, Maritime, Rail and **HGV** applications
- MW-scale AC & DC power supplies 1 MVA 4-quadrant power supply capable of operating in AC and DC modes; 3-phase and single phase AC power supply capability; up to 3kV DC capability
- · Brings additional Hardware-in-the-Loop capability to existing multi-MW PNDC capability
- MW-scale test bed for machines and drives
- · Complemented by partner capabilities at the University of St Andrews (hydrogen platforms), University of Edinburgh (semiconductor device and converter capability), University of Glasgow (semiconductor R&D), NMIS (design and manufacturing) and Michelin Scotland Innovation Parc (MSIP)



# **Network Partners**





The Magnetic Materials Group (MMG) at the University of Birmingham is the only UK research group focused on processing and recycling permanent rare earth magnetic materials. The MMG is internationally recognised for its work on hydrogen processing of rare earth alloys and magnets which are used worldwide in the production and recycling of Neodymium-Iron-Boron (NdFeB) magnets. The Group has been in existence for over 45 years under the leadership of Professor Rex Harris, Dr Andy Williams and now Professor Allan Walton.

- Large scale recycling and production facility for rare earth permanent magnets
- Machining and finishing equipment
- Characterisation facilities for magnetic materials
- · Bench scale magnet processing equipment



# University of Bristol

The University of Bristol's Electrical Energy
Management Group has an excellent track record
of long-term strategic partnership with industry,
encompassing both TRL 1-5 support of research and
development and skills training, with a strong power
electronics and machine drives focus. Furthermore, it
also has a history of supporting SME aided funding
schemes such as KTPs, UKRI grants, and Impact
Acceleration Awards. Capabilities in this area include:

- Design studies into electrical machine and power electronic convertors customised to bespoke energy conversion applications
- Detailed forensic experimental and model based examination of electrical machine and power conversion to understand where performance falls short of expectations and sources of parasitic loss or premature failure





# Centre for Process Innovation (CPI)

CPI connects the dots in the innovation ecosystem to bring ideas to life. CPI is a social enterprise accelerating the development, scale-up and commercialisation of deep tech and sustainable manufacturing solutions. It partners with various industries to create sustainable innovations for people and the planet; as a High Value Manufacturing Catapult member, it provides access to top organisations.

- High throughput formulation and automation equipment
- Advanced characterisation facilities
- Batch and roll to roll coating capabilities
- In slot die and screen printing
- Materials synthesis capability, including raw materials and ability to develop recycling processes
- Modelling, informatics and data science
- Process optimisation and scale-up, including process engineering design



### Compound Semiconductor Applications Catapult

The Compound Semiconductor Applications (CSA) Catapult's purpose is to deliver long-term benefit to the UK economy and accelerate UK economic growth in industries where applying compound semiconductors creates a competitive advantage and enables new products or end markets. Its vision is for the UK to become a global leader in developing and commercialising new applications for compound semiconductors.

- Power electronics lab design and characterisation of high performance devices and modules
- RF and microwave lab supports development of leading edge products in multiple sectors
- Photonics lab supporting customer breakthroughs in optical sensitivity and beam control
- Advanced packaging line leadingedge package design and development including thermal optimisation





With a proud tradition, Coventry University's research and innovation aims to address real-world challenges. Its research into future transport solutions takes place in the birthplace of the British motor industry. Coventry University supports DER-IC through its Centre for Advanced Low-Carbon Propulsion Systems (C-ALPS) and Institute of Advanced Manufacturing Engineering (AME). C-ALPS combines academic expertise and state-of-the-art facilities in battery and supercapacitor cells, hydrogen fuel cells, e-motors and drives. AME blends research and training activities in a unique 'Faculty on the Factory Floor' initiative with expertise in metrology, digital processes and laser joining.

- Hydrogen and electric propulsion system test
- **Pre-compliance EMC test chamber**
- Power-semiconductor device characterisation

Coventry University

**Advanced manufacturing and materials** 



CSconnected is the collective brand for a growing number of advanced semiconductor related activities in Wales, home to a unique community of academic institutions, prototyping facilities and global, high-volume manufacturing capabilities that collaborate across a range of research and innovation programs. Capabilities available across the CSconnected cluster:

- Power semiconductor R&D a range of materials expertise in Si. SiC. GaN and other advanced semiconductor technologies at TRLs 1 - 3
- Power semiconductor design and test high voltage power lab for design, test and prototyping of power electronic applications at TRLs 4 - 6
- Manufacturing processes equipment and processes for manufacture of power semiconductor devices



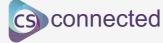
The School of Engineering addresses diverse complex challenges across the entire field of engineering. Its Electrical Power Conversion Group has a long track record in electrical power technologies for renewable energy applications. This includes designing, modelling and testing electrical machine and power converters for some of the leading companies in offshore renewable energy.

- Electrical machines lab
- Power electronics lab
- · High temperature superconducting lab



The James Watt Nanofabrication Centre (JWNC) is a 1200m<sup>2</sup> cleanroom at the University of Glasgow which houses over £35M of state-of-the-art fabrication and metrology equipment. It is one of the leading centres of research and international collaboration in micro and nanofabrication technologies undertaking fundamental, applied and commercial research, and small industrial prototyping and production runs.

- James Watt Nanofabrication Centre
- B1505 power semiconductor analyser
- Characterisation equipment for power semiconductor devices together with a high temperature on-wafer probe station









### Loughborough University

Loughborough University is an international leader in High Value Manufacturing (HVM) research, with a leading-edge PEMD research portfolio in the areas of control systems, energy systems and advanced materials and manufacturing. It works closely with industry through funded research and exploitation of cutting-edge technologies across aerospace, energy, marine, rail and automotive industrial sectors.

- Ultrasonic assisted bonding systems
- Advanced auto-lab electrochemical station
- Helios G4 PFIB UXe DualBeam Microscope
- Measurement of thermal conductivity
- Advanced thin films and coatings for interconnects
- COMSOL Multiphysics modelling



The eTransport research area at the University of Manchester is concerned with the electrification of land, air and sea transport. It focuses on developing solutions that lead to more efficient, higher power density and lower emission systems achieved through the use of advanced materials, improved manufacturing processes and the development of new analytical methods. All technologies will make a strong contribution towards achieving the 2050 zero

- MEA aerospace laboratory IEPNEF
- National grid high voltage laboratories
- Cryogenics test facilities

**University of** 

**Manchester** 



### **Manufacturing Technology** Centre (MTC)

The MTC is a catalyst for the future growth of innovative, world-leading technologies. With vast experience in state-of-the-art developments, industrialisation of processes and development of organisational strategy, the MTC provides derisking and enablement across all manufacturing sectors, including those focused on electrification.

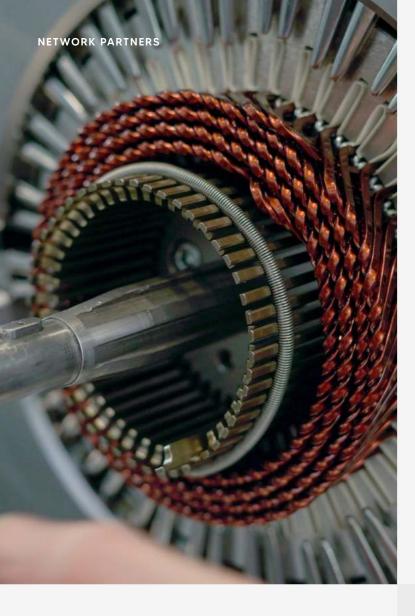
- National Centre for Additive Manufacturing (NCAM) - metals, polymers, ceramics
- Laser cutting, joining, cleaning, and surface texturing - including red, green and blue sources
- Automation and robotics adoption and implementation
- Digital Twin and process simulation development
- · Supply chain assessments and development
- Product development Design for Manufacture / Assembly
- Advanced Manufacturing Training Centre (AMTC) - apprentice through to C-Suite level











### **Michelin Scotland Innovation Parc (MSIP)**

MSIP is a dynamic and creative home for innovators, manufacturers and skills leaders who are actively working towards reducing carbon emissions and fostering a cleaner, more sustainable future. MSIP offers space to manufacture and scale-up; business, skills and innovation support; and access to green energy from sustainable sources.

- Innovation Labs workshops starting at 73m<sup>2</sup>, designed for short-term, flexible project use, each includes standard power, with some offering 3-phase power and water
- Makerspace including mechanical and electronics labs, equipped with a 3D printer, laser cutter, pillar drill and various tools
- The Skills Academy offering access to resources including skills, training and equipment





The National Composites Centre (NCC) is the UK's centre of excellence for the development and application of composite materials. The NCC specialises in identifying and solving challenging problems through the application of advanced design and simulation tools, expert knowledge of all kinds of composite materials and world-leading manufacturing facilities.

- · Open access technology testbed for advanced composites
- Vast array of automated manufacturing processes
- Tensioned fibre winding
- In-process manufacturing control and inspection
- · Multidisciplined design and simulation
- · High temperature materials (ceramic and polymer)
- Broad range of integrity & verification technology
- Life cycle analysis



### **National Manufacturing** Institute Scotland (NMIS)

The National Manufacturing Institute Scotland (NMIS) is a group of industry-led manufacturing R&D, innovation and skills facilities operated by the University of Strathclyde and supported by a network of partners across Scotland. The group has a national mandate to create and deliver inspiring, sustainable and translational research and skills for all by accelerating innovation in the manufacturing community.

- · Industrial-scale superconducting windings
- Incremental near net shape forming and forging
- Materials science and residual stress characterisation
- Lightweight Manufacturing Centre





NPL is the UK's National Metrology Institute, providing the measurement capability that underpins the UK's prosperity and quality of life.

- Future factory for high performance electrical
- Suite of traceable measurement capabilities
- Bespoke reliability tests on materials, devices and interconnects
- **Custom semiconductor imaging equipment**



The Newcastle University Electrical Power Research Group has an established record of academic excellence and innovative, multi-disciplinary, industrially collaborative electrification research, focusing on developing high-efficiency, power-dense electrical machines, drives and power converters. Research greas include semiconductor devices. switch control, converter topologies, thermal management, electric drives, electrical machine design, and energy storage. Its capabilities to conduct these projects include:

- Electrical Power Research Laboratory extensive state-of-the-art test facilities
- Battery, Power Systems, and Smart Grid
- Cleanrooms class 100 for fabrication of custom (SiC) power devices and modules
- Future Electrical Machines Manufacturing Workshop
- Design Unit electrical and mechanical manufacturing and test equipment, specialising in gear technology





Northumbria University is a well-regarded research institution specialising in electrical power and control systems. Its Electrical Power and Control Systems Research Group researches various topics, including renewable energy, power electronics, electric vehicles, and related areas.

- · 3D rapid prototyping service printing solutions with Computer Numerical Control (CNC) and conventional machining capabilities
- Structural integrity testing testing of prototype structures to explore failure modes, acceptance testing, and define design rules
- Environment testing (Portable X-Ray Fluorescence (XRF) testing) - determining the chemical composition of materials, mobile air quality measurement and monitoring systems
- Surveying, scanning and construction capability-LIDAR, photogrammetry and infra-red scanning





The Power Electronics and Electrical Machines Centre (PEMC) at the University of Nottingham is one of the largest groups of its kind worldwide, with over 170 researchers and 5,000m<sup>2</sup> of dedicated research and development space. The Centre hosts the UK-EAPF (UK Electrification of Aerospace Propulsion Facility) and the Future Factory for High Performance Electrical Machines. PEMC research ranges from basic technology investigation to fully engineered advanced concept demonstrators, carried out in experimental facilities that allow realistic practical validation of novel components and systems.

- Future Factory for Advanced Electrical Machines
- Power electronics integration facilities
- Power electronics characterisation facilities
- **UK Electrification of Aerospace Propulsion Facility**









# Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

The Nuclear AMRC helps companies in low-carbon industries to improve their manufacturing quality and performance. Core technology areas include digital engineering, controls and instrumentation, joining, machining and metrology. Based at the University of Sheffield, with additional facilities in Derby and Warrington, the Nuclear AMRC is part of the High Value Manufacturing Catapult.

- Equipment qualification laboratory, including shaker tables
- Production-scale workshop with advanced machining, joining and fabrication technologies
- Additive manufacturing laboratory with capabilities for a variety of metals and polymers and 3D-printed electronics

**NUCLEAR AMRC** 

- Metrology laboratory, including large-volume gantry CMM and non-contact measurement
- Digital engineering workshop, including industrial digital technologies testbed, and tracked mixed-reality cells



### Offshore Renewable Energy (ORE) Catapult

ORE Catapult is the UK's leading technology innovation and research centre for offshore renewable energy. ORE Catapult's National Renewable Energy Centre in Blyth, Northumberland, is home to the world's most comprehensive open access research, test, innovation and validation services to accelerate the deployment of new and innovative offshore renewable energy technology.

- 1MW Drivetrain test facility
- · 3MW Drivetrain test facility
- 15MW Drivetrain test facility
- 'e-Grid' grid emulation



University of Southampton



PNDC is an established whole energy systems innovation facility with significant track record in delivering accelerated, development, testing and demonstration projects in a controlled, real-world environment for the energy sector and high power / high integrity transport applications including aviation, marine, HGV, off-highway, and rail.

- DER funded High-Power Propulsion and Powertrain Systems Validation Capability
- Power hardware-in-the-loop testing capability up to 1MW
- Configurable 11kV and LV distribution network
- MW-scale onsite generation
- Real-time digital simulator (RTDS) for power system modelling and hardware in the loop simulation





The Electrical Machines and Drives (EMD) group at the University of Sheffield is renowned for its pioneering research on permanent magnet electrical machines. It hosts six industrially-funded research centres, including the Rolls-Royce University Technology Centre in Advanced Electrical Machines, the Siemens Gamesa Renewable Energy Research Centre, and the £28M EPSRC Future Electrical Machines Manufacturing (FEMM) Hub.

- Dynamometers 15kW at 51,000rpm; 120kW at 18,000rpm; 250kW at 14,000rpm
- Electrical test equipment including Cropico DO5000 high-accuracy microhmmeter; Schleich MTC2 surge tester up to 6kV; Wayne Kerr Electronics 6500B series 50MHz impedance analyser
- Thermal test equipment including environmental chambers with 10kW load capability down to -55°C





### University of Sheffield -Advanced Manufacturing Research Centre (AMRC)

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is a world-class research centre specialising in advanced manufacturing technologies for aerospace, automotive, medical and other high-value industries. Alongside the wider PEMD activities at The University of Sheffield, the AMRC supports PEMD development, testing, and industrialisation. The AMRC has expertise in creating lightweight components for PEMD through machining (including shafts, hubs, gears), casting, additive manufacturing, and composites, plus specific capabilities including:

- Remote laser cutting cell novel high-speed processing of electrical steels
- Coil winding robotic needle winding, linear coil winding, heated press
- High tension filament winding in-situ and ex-situ manufacture and testing of rotor containment sleeves



#### University of Southampton

The Faculty of Engineering and Physical Sciences (FEPS) at the University of Southampton undertakes internationally leading research in energy storage, electronics, high-speed electric machine design, cryogenic and superconducting magnetic systems, and system integration in the fields of electric vehicles, rail, aerospace, maritime, and autonomous systems.

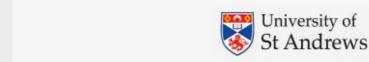
- Testbed for 100kW superconducting electric machines at 60-77K
- Electrochemical engineering laboratory
- Towing tank
- National wind tunnel test facility for aerospace and UAV testing



# University of St Andrews

The University of St Andrews is renowned for its fundamental research in energy topics such as energy storage, sustainability and energy and ethics. The University has particular research strengths in low carbon technologies. Within its 'energy, environmental and sustainable chemistry' theme are topics such as materials for energy storage and synthetic fuels, solar energy, critical raw materials and pollution, which provide real solutions for today's world problems.

- Electron microscope facility
- Fabrication and prototyping facility
- Dry room laboratory









# University of Strathclyde

The University of Strathclyde's Institute for Energy and Environment (InstEE) is nationally and internationally recognised as a leading academic research centre for electrical power systems, and energy and electrification technologies. InstEE is well resourced with cutting edge experimental infrastructure, supporting academic research, extensive industry engagement, and international cooperation. This sees the team advance the design, prototyping, testing and systems integration of power electronics for smart grids, microgrids, aerospace, marine and other heavy-duty transport applications. Alongside simulation suites and PNDC, the state-of-the-art facilities available for industrial collaboration include:

- Dynamic Power Systems Lab
- Aero-Electrical Protection Lab
- Power Electronics, Drives and Energy Conversion Lab
- Applied Superconductivity Lab





The Centre for Integrative Semiconductor Materials (CISM) at Swansea University combines semiconductor and advanced materials platforms and processes to deliver technologies and products via an Open Access Fab Pilot model. CISM includes a facility for wafer-level processing of Silicon Carbide Power Electronic Components – the UK's national industrial pilot line for SiC power electronic components. R&I services include:

- Advanced electron microscopy (TEM, SEM, FIB)
- Surface chemical analysis and multi-functional scanning probe
- Multi-wafer batch wet etch stations and comprehensive dry etch capability
- Advanced atomic layer, physical vapour, chemical vapour, and molecular vapour deposition
- Component modelling and design suite Component stress and failure testing
- Thin film analysis (ellipsometry, spectrophotometry)



Cyfadran Gwyddoniaeth a Pheirianneg Faculty of Science and Engineering

# Teesside University

Teesside University School of Computing, Engineering & Digital Technologies has two key research centres - the Centre for Sustainable Engineering and the Centre for Digital Innovation. Some of the research activities are focused on the decarbonisation of industry and society, using engineering approaches spanning the disciplines of electrical and electronic engineering, instrumentation and control engineering, chemical and materials engineering, civil engineering, computational mechanics, robotics, virtual reality, artificial intelligence, and biomechanics.

- · Simultaneous thermal analyser
- Digitalisation of Power Electronics, Machines, and Drives
- Circular economy and non-mechanical recycling
- Materials for electrical machines in extreme environments
- Electrical insulation materials for high performance



# University College London (UCL)

Advanced Propulsion Lab (APL) is a cutting-edge electrical system engineering centre focused on developing and characterising high-power and energy, zero-carbon propulsion systems. The centre brings together experts in batteries, hydrogen generation and utilisation, electric motors, and power electronics to deliver research and teaching capabilities at scales directly relevant to industrial partners. The centre is designed to facilitate the creation, construction, characterisation, and validation of cutting-edge industrial-scale propulsion systems, leveraging this capability to support the UK's commitment to achieving zero-carbon targets.

- Unique facility to develop, test and characterise batteries, fuel cells, power electronics drives and electric motors
- Complete facilities for full electric system testing
- Advanced packaging capabilities for system-onchip and power ICs



### The Welding Institute (TWI)

TWI is a membership-based organisation helping individuals and companies to design, create and operate the best products possible. Descending from the British Welding Research Association (BWRA), TWI has grown into one of the foremost independent research and technology organisations, spanning innovation, knowledge transfer and problem resolution across all aspects of welding, joining, surface engineering, inspection and whole-life integrity management.

- EB welding
- LASER welding
- Friction welding
- NDT capability (PAUT, UT, XRAY)



# The University of Warwick

The University's School of Engineering is home to the PEATER (Power Electronics Applications and Technology in Energy Research) Group, founded in 2005 to establish a world class centre for research into power electronics, power semiconductor devices and applications in power systems and power conversion. The focus is on electrical energy conversion and semiconductor switching devices. Developments in MOSFET and IGBT technologies are delivering new applications for electrification of vehicles, aircraft, ship propulsion, wind turbines and the revolution in mobile phone and computing devices.

- · Power electronics reliability suite
- Clean rooms for manufacture and packaging of semiconductor devices
- ISO class-8 packaging cleanroom
- · Power and control systems research laboratories
- · Chemical vapour deposition reactor
- Doctoral training centre, industry learning and development courses



# WMG at The University of Warwick

WMG is an academic department at The University of Warwick and the leading international role model for successful collaboration between academia and the public and private sectors, working with over 1,000 companies cross-sector. WMG is also a High Value Manufacturing Catapult (HVMC) Centre, driving growth and productivity by accelerating and de-risking innovation to deliver powerful solutions for industry. The WMG Centre leads for HVMC on net zero mobility, with major roles in energy / electrification, intelligent vehicles and digital technologies.

- Winding Centre of Excellence
- Wireless charging
- Advanced Propulsion Research Laboratory
- Advanced Steel Research Centre
- Energy Innovation Centre battery materials scale-up line (mixing, coating and cell building, testing, characterisation, and in-use / abuse testing)
- Industry learning and development provision through the WMG Skills Centre







# **Industry Engagement**

#### **Inverter Testing Facility at The University of Warwick**

Innovative inverter testing equipment has been developed by Professor Phil Mawby and his team at The University of Warwick's School of Engineering following almost £900k funding from the Driving the Electric Revolution Challenge. The University's WMG Centre High Value Manufacturing Catapult (HVMC) also contributed £300k of funding.

The equipment has been designed to help speed up the development of electric vehicles (EVs) and reduce testing costs for British manufacturers. The facility was used for the first time by premium car manufacturer BMW to test a new power inverter.

Previously, car manufacturers tested inverters with motors at high-cost dynamometer facilities with concrete bunkers that contained high speed equipment failures. This newly designed equipment is smaller, less costly, easier to access and allows manufacturers to test components in isolation – i.e. the inverter – without the motor. This technology is also applicable to other sectors.

BMW is one of the businesses behind @FutureBev, a project group made up of six partners including The University of Warwick and CSA Catapult, who have come together to develop a UK supply chain that can support the transition of BMW to SiC-based power electronics in their future generations of BEV (Battery Electric Vehicle). This will ensure competitive powertrains in function and costs and enable UK technology transformation to zero emission mobility.





### Low Carbon Transport Applications Centre (LOCATE)

As part of DER-IC Scotland, the Hydrogen Accelerator has attracted £4M of investment from Transport Scotland to fund the new LOCATE facility (Low Carbon Transport Applications Centre). The project is being led by the Hydrogen Accelerator (University of St Andrews and University of Strathclyde). This is part of a pipeline of support preceded by the DER funded equipment at PNDC (University of Strathclyde) which provides sub-systems and powertrain testing and de-risking prior to platform level testing at LOCATE.

DER-IC has helped to facilitate this partnership through its connections with partners the University of St Andrews, which specialises in batteries, fuel cells and hydrogen; and the University of Strathclyde, which has expertise in energy systems, power electronics, machines and drives. LOCATE provides a first of a kind, platform level, route-to-market Power Train Test Bed (PTTB) for hydrogen fuel cell and battery electric drive trains.

LOCATE will form part of a Low Carbon Transport Programme being jointly developed between Scottish Enterprise and Transport Scotland. The LOCATE test facility will provide an 'emulated' representation of real world duty cycles for a variety of heavy-duty road / niche vehicles. This replaces and brings forward what would traditionally have been on-road testing. It is aimed at platform level testing at TRL levels 5-7 and will reduce cost and time to market for the users.

#### **UK-Alumotor**

UK-Alumotor received £2.85M funding from the UKRI Driving Electric Revolution Challenge fund.

A consortium of key industry partners was formed to develop the UK's electric motor supply chain by leveraging its manufacturing expertise to deliver the next generation of sustainable electric motors.

DER-IC network partner Warwick Manufacturing Group (WMG) was part of the consortium along with Ricardo, Aspire Engineering, Brandauer, Phoenix Scientific Industries and Global Technologies Racing.

Over the duration of the project, the partners identified and developed preferred manufacturing processes which are suitable for volume production of the patented motor design from a UK supply chain, whilst refining the design to meet the future requirements of their UK and international stakeholders. The project supported the UK's net zero ambitions by developing a more affordable, environmentally sustainable design which displaces the need for scarce material resources, resulting in a greener and more affordable solution to support the mass adoption of electrification. Training the next generation was also a focus and UK-Alumotor was committed to growing the UK's PEMD manufacturing capability and training the next generation of skilled engineers and technicians, positioning the country at the forefront of the global electric revolution.





#### **H2GEAR**

The H2GEAR programme, involving leading academics at Newcastle University's School of Engineering and led by GKN Aerospace, will be at the heart of the technological developments needed for the future of more sustainable aviation.

The programme has access to equipment at the DER-IC North East in Sunderland, including a power electronics assembly line and a flexible electric machines assembly line. The Newcastle University team will use their understanding of electronic materials, power electronics and electrical power networks to develop an ultra-high efficiency power and propulsion system that will provide the backbone of this advanced technology.

The programme will develop a cryogenically enhanced propulsion system for short-distance aircraft that could be scaled-up to larger aircraft. Liquid hydrogen is being converted to electricity within a fuel cell system which efficiently powers the aircraft and eliminates all harmful CO<sub>2</sub> emissions.

H2GEAR will create a new generation of clean air travel and reinforce the UK's position at the forefront of aerospace technology research and development. Newcastle University's collaboration with GKN Aerospace, Intelligent Energy, Aeristech, University of Manchester and University of Birmingham is expected to create more than 3,000 jobs in the next decade.

The programme is supported by £27M of Aerospace Technology Institute funding, matched by GKN Aerospace and its industrial partners to make a total investment of £54M.

### **Testimonials**

"@FutureBEV with Warwick University is demonstrating the ability of industry and academic partners coming together to deliver accelerated technologies to market. The access to a strong academic base with matched development and test hardware enables rapid implementation of ideas from drawing board to real hardware. The investment from DER-IC is one of the enablers for this ensuring the facility is tooled with the latest test equipment, meaning the university is ready and able to support business. The @FutureBEV team directly benefit from quick access to the BEV specific test equipment enabling risk reduction as well as improving the change of emerging technologies to be implemented in new designs. The net benefit is through this collaboration we can bring these CO<sub>2</sub> reducing technologies to the road quicker whilst keeping the business case and enabling a next generation of engineers."

David Bock, Project and Technical Lead for @FutureBEV, BMW Group

"It is essential that the UK reacts quickly to the growing market demand for electric motors and power electronics systems, scaling up capacity at every level within the supply chain. AEM is already working closely with the DER Industrialisation Centres to deliver a truly sustainable end-to-end supply chain for our unique, rare earth free, high performance motor technologies."

Mike Woodcock, Chief Commercial Officer, Advanced Electric Machines

"Rolls-Royce believes the DER Industrialisation Centres play an important role helping the supply chain to access both manufacturing process development and scale-up and test capabilities, and that they will ultimately support us as we develop our electrification capability and solutions."

Eddie Orr, Head of Research Partnerships, Rolls-Royce Electrical

"McLaren Applied is working alongside DER-IC North East in its grant funded programme SCIENZE (Supply Chain Innovation for Net Zero). The expertise of DER-IC North East, particularly around automation of power electronics based products, is key to ensuring McLaren Applied stays innovative and competitive in not only power electronics product design but also in manufacturing process technology."

Steve Lambert, Head of Electrification, McLaren Applied

# **Working Together**

Power Electronics, Machines and Drives (PEMD) form the foundation of critical control and motion technologies across all sectors.

The Driving the Electric Revolution Industrialisation Centres (DER-IC) are a UK-wide network of over 30 Universities and Research and Technology Organisations (RTO). Each network partner brings expertise, specialist knowledge and capability.

For access to the full DER-IC network capability, contact your local DER-IC.





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DER\_IC\_UK in DER Industrialisation Centres

The information in this brochure is correct as of August 2023. For our latest partner and equipment information, please visit our website: www.der-ic.org.uk

