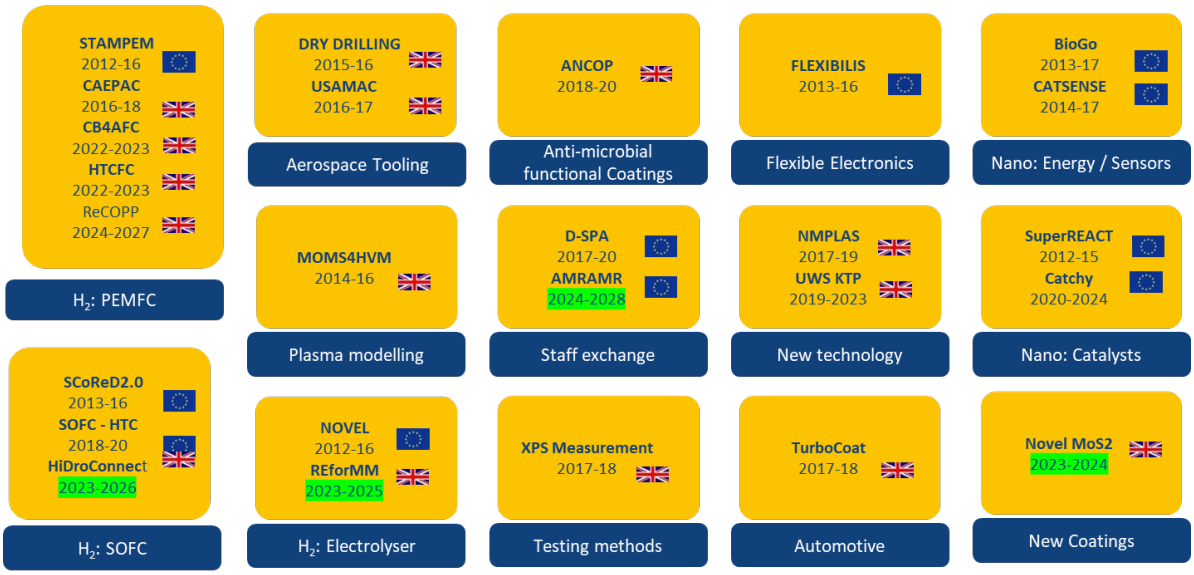
Recent EU & UK funded Research Projects

multi millions in total of EU/UK grant funding…



Completed projects:

- **Diamond-based nanomaterials and nanostructures for advanced electronic and photonic – D-Spa**

Funded By: EU: H2020-MSCA-RISE-2016 (Marie Skłodowska-Curie Research and Innovation Staff Exchange)
Period: 2017-2023

The objective of the proposed joint exchange programme is to establish long-term stable research cooperation between the partners with complimentary expertise and knowledge. The project objectives and challenges present a balanced mix between industrial application focused knowledge transfer and development and more far-looking studies for potentially ground-breaking applications of using diamond-based nanomaterials and nanostructures for advanced electronic and photonic applications (D-SPA), including fabrication of diamond nanostructures using 3D printing technology, development of diamond-plasmon hybrid photonic devices and development of biophotonic imaging technology for sensing applications. No one group in Europe can

accomplish each work package alone. We have to collaborate with each other in order to gain their skills and expertise in these specific areas.

Partners:
Aston University, UK (Aston); Cork Institute of Technology, Ireland (CIT); Institute of Nanoscience and Nanotechnology, Spain (ICN2); University of Birmingham, UK (UoB); Zhejiang University of Technology, China (ZJUT); Nanotechplamsa Ltd, Bulgaria (NPL), B&T composites, Greece (B&T); National Institute for Research and Development in Electrical Engineering, Romania (ICPESA)

- **HTCFC: High-Throughput Coating Processes for Fuel Cell Bipolar Plates**

  Funded By: InnovateUK: moving the UK automotive sector to zero emissions
  Period: 2024-2027

Proton Exchange Membrane Fuel Cells (PEMFCs) display the highest power densities of any of the fuel cell types, which makes them particularly attractive for transportation & portable applications where minimum size and weight are required. Conventional PEMFCs utilise bipolar plates which are made from graphite (bulky and expensive to machine) or stainless steel. Stainless steel bipolar plates (BPPs), which are dominant in automotive PEMFCs, require a protective coating to achieve the desired performance and lifetime. Hundreds of cells are required within an automotive multi-kW stack, hence it is important to develop coating processes which provide high throughput and economic production of coatings. It is also highly desirable to deposit coatings on metal sheets prior to the forming of bipolar or separator plates, without the coating being adversely affected by the subsequent forming processes. This project will evaluate the feasibility of scale up of high-performance fuel cell.
BPP coatings in a semi-continuous inline coating deposition equipment, and the effect of scale-up on critical performance characteristics as well as the cost of production of coatings. The effect of scale-up will be evaluated both for coating of pre-formed fuel cell plates and on plates formed post coating, in order to inform decisions on the most appropriate future scale up processes.

Partner:
The University of Birmingham, UK

- **High-Performance Electrode Plate Coatings for Lightweight Fuel Cell Stacks (HiPerEPC)**

  Funded By: InnovateUK: Industrial research
  Period: 2020-2021

Air-cooled fuel cells are particularly suitable for lower power automotive applications such as primary and range extender drives for lightweight vehicles. Their rapid refuelling capabilities, combined with significantly reduced balance-of-plant complexity, hence minimising weight (and cost), provide a clear differentiator from pure battery powered solutions. HiPerEPC exploits previous feasibility research (CAEPAC) and will deliver novel high performance coatings for Proton Exchange Membrane fuel cell (PEMFC) electrode plates based on lightweight alloy substrates. PEMFCs display the highest power densities of any of the fuel

cell types, which makes them particularly attractive for transportation & portable applications where minimum size and weight are required. Conventional PEMFCs utilise electrode plates which are made from graphite (bulky and expensive to machine) or stainless steel. For automotive applications, hundreds of cells are needed within a multi-kW stack, hence a relatively small weight saving per plate will be significant for the whole system. Specific power densities delivered by aluminium-based fuel cell systems can be double that of stainless steel-based ones but challenges remain in optimising the high-conductivity coatings which are essential to protect aluminium bipolar plates against corrosion in the acidic fuel cell environment. HiPerEPC will refine the promising coatings identified in CAEPAC to enable the use of aluminium electrode plates in fuel cell stacks and provide essential evidence of their critical performance characteristics and manufacturing costs to support investment decisions on future scale-up.

Partner:

The University of Birmingham, UK

- **KNOWLEDGE TRANSFER PARTNERSHIP between University of the West of Scotland and Teer Coatings Limited (UWS-KTP)**

  Funded By: InnovateUK: (KTP)
  Period: 2020-2023

  To embed optical coatings expertise, particularly in plasma assisted deposition, in order to develop a new range of optical coating machines and optical coating services (application of optical coatings onto customer parts and components by TCL).

  TCL's strategy is continual investment in modern equipment & R&D, maintaining a worldwide lead in thin film coating technology, which is exploited commercially. TCL's line of coatings' products include solid lubricant coatings & hard wearing coatings. Customers are from motorsport, medical & high performance industrial sectors where long-term component performance in demanding engineering applications is required.

  To capture this opportunity, TCL is seeking to embed emerging research from UWS (patented plasma assisted precision sputter deposition technology) to underpin the development of a new optical coating system (based on TCL's existing Magnetron plating hardware) which it can sell as a complete NEW system plus offer a new in-house optical coatings service at TCL's premises for customers' free-issued parts.

  Partnership:
  University of the West of Scotland, UK

- **Antimicrobial coatings by physical & chemical vapour deposition for application in aerorospace (ANCOP)**

  Funded By: InnovateUK: (Shanghai-UK Industrial Challenge Programme – Open)
  Period: 2018-2020

Microbial and fungal growth in space environment are important challenges for the space industry. Typically, the number of microbial organisms is controlled through extreme disinfection and quarantine of astronauts but there is no established means of eliminating the organisms once in the space environment. The ANCOP project is focused on exploiting the disruptive innovation involving nano-cluster enabled Physical Vapour Deposition (PVD) coatings, nano-composite PVD coatings and functionalised Chemical Vapour Deposition

(CVD) diamonds to address the problem of microbial growth in space environment both on surfaces and critical components in manned satellites. Nano-cluster enabled PVD & nano-composite PVD coatings will enhance and retain surfaces' antimicrobial properties by controlling the size of silver nanoparticles in the coatings. In parallel, CVD-deposited functionalised diamond will be developed, adding anti-microbial functionality to the hard, wear resistant and/or decorative aspects of that coating. Post-project, similar coatings will also be exploited in terrestrial environments, including healthcare, agri-food & transport (automotive, aerospace, rail, marine, etc.).

Partners:
Aston University (AU), Birmingham City University (BCU) and Shanghai Aerospace Equipments Manufacturer (SAEM).

- **Advanced XPS Measurements for High Performance Coatings (ADVACEXPS)**

Funded By: InnovateUK: (Shanghai-UK Industrial Challenge Programme – Open)
Period: 2017-2018

High performance coatings for application in catalysis, such as coated polymer electrolyte membrane fuel cell bipolar plates and photocatalysis have narrow tolerances on critical film properties such as thickness, uniformity, chemical composition and defect density. There is a need for measurement tools which can provide accurate data about these properties in a non-destructive and rapid manner. Teer Coatings Limited (TCL) has identified an urgent need for measuring such coating properties for very thin (a few nanometre) layers, which cannot be readily assessed by conventional measurement techniques. This expresses a wider requirement for such capability, which could be met by recent advances in surface analytical instrumentation and theory. The purpose of this project is to establish the technical feasibility of using advanced X-ray photoelectron and ion scattering techniques to deliver critical coating parameters for process optimisation and future routine QA monitoring.

Partners:
National Physical Laboratory, UK; Kratos, UK

- **Novel microwave plasma sputter deposition process, enhanced durability coatings NMPLAS**

Funded By: Technology Strategy Board: Materials & Manufacturing Round 2
Period: 2017-2019

The NMPLAS project is focused on an innovation in the Materials and Manufacturing high growth sector and will apply a cutting edge and innovative, high throughput coating process - Microwave Plasma Assisted Sputtering (MPAS), to produce infrared (IR) transparent and hard, wear/erosion resistant coatings, which are themselves an innovation in materials development. The coatings will be applied on an expanded range of thermally sensitive and strategic substrates, which will initially be exploited in the optical and automotive high value manufacturing sectors, thereby opening up new sustainable business for the partners and increasing the UK's competitiveness, in addition to the transfer of techology to the industrial partners in the project (enabling a step-change in capability for an SME) and opportunities for future growth in capital equipment sales.

Partners:

Qioptiq Limited (QUK), UK; Helia Photonics Ltd (HPL), UK; the University of the West of Scotland (UWS), UK

- **High Temperature Coatings for Low Inertia Turbocharger Turbine Wheels (TurboCoat)**

Funded By: Technology Strategy Board: Surface Engineering and Coating Technologies for High-Value Manufacturing
Period: 2017-2018

Project is to research new coatings for use on low inertia turbocharger components as an enabler technology for the adoption of new advanced base materials. The project will focus on the turbine wheel which today is manufactured from Inconel, a very dense nickel alloy. New base materials are being developed by the turbocharger industry for lower inertia, in particular, Titanium Aluminide (TiAl). However as exhaust temperatures for petrol engines are increasing beyond 1000 Deg. C. this material will require surface coatings to be durable in this extreme environment. This project will research magnetron sputtered coatings and application techniques that will enable the new base material to withstand the harsh environment of a turbocharger. Small scale sample tests will be run to establish which combinations of coatings and the base material perform the best and are worthy of taking through to full validation testing. While the use of TiAl in turbine applications is not new, there are recognised limitations to its application which this novel work is intended to address, such as its susceptibility to erosion and high temperature corrosion.

Partners:
University of Huddersfield, UK

- Coated Aluminium Electrode Plates for Air-Cooled (AC) PEMFC (CAEPAC)
  Funded By: Technology Strategy Board: Lightweight vehicle and powertrain structures
  Period: 2016-2018

  CAEPAC will establish the feasibility of coated electrode plates of lightweight alloy substrates for PEM (Proton Exchange Membrane) fuel cells. PEM fuel cells display the highest power densities of any of the fuel cell types, which makes them particularly attractive for transportation & portable applications where minimum size and weight are required. Air cooled fuel cells significantly reduce balance-of-plant complexity, hence weight (and cost), making Intelligent Energy's AC (Air Cooled) technology particularly suitable for lower power automotive applications such as primary and range extender drives for lightweight vehicles. Conventional PEM fuel cells utilise electrode plates which are made from graphite (bulky and expensive to machine) or, particularly for transport, stainless steel. For automotive applications, 100's of cells are needed within a multi-kW stack, hence a relatively small weight saving per plate will be significant for the whole system, provided such components can be manufactured cheaply and with similar performance and longevity. CAEPAC will develop novel, coated lighweight alloy plates, and investigate their performance in cells and stacks, with detailed post-mortem analysis.

Partners:
Intelligent Energy, UK; WMG, Warwick University, UK

- **ULTRA SONIC ASSISTED MACHINING OF AEROSPACE COMPOSITES (USAMAC)**

  Funded By: National Aerospace Technology Programme
  Supply Chain Technology Development Projects
  Period: 2016-2018

  The project exploits advances in machine tool operation (ultrasonic assistance), cutting tools (design, materials & manufacturing), and advanced coating technology (for abrasion resistance, thermal stability, and friction control). Building on previous research and state of the art knowledge, the consortium will combine these recent advances and optimise the resulting machining process and tool strategies to provide a new level of performance in the manufacture of aircraft including the main structures of the fuselage and wings.
  The benefits of Ultrasonic Assisted Drilling have only recently been recognised and WMG is pioneering the application of this technology in the UK. To date, development has been restricted to conventional tooling and there is a unique opportunity to accelerate and maximise the impact of this technology through the development of bespoke tooling and its associated coatings.

Partners:
Kyocera Unimerco Tooling Ltd, UK; Warwick University, UK

- **Design of novel high performance catalysts and biosensors based on deposited mass-selected clusters assisted by computational theoretical screening (CATSENCE)**
  Funded By: EU: SEVENTH FRAMEWORK PROGRAMME; THE PEOPLE PROGRAMME; FP7-PEOPLE-2013-ITN
  Period: 2014-2017

  The main S&T objective of CATSENSE is to design novel high performance catalysts and biosensors by a new interactive approach combining i. the production of mono- and bimetallic gas-phase clusters of controlled homogeneity, ii. the extensive characterization of their morphology, structure (ex and in situ) and optical properties, iii. theoretical modelling and screening, and iv. catalytic and biosensing laboratory tests. Prototypes of the most promising catalyst and biosensor will be tested in realistic operative conditions through intense collaboration with our industrial partners. Biosensing and catalysis applications are of paramount importance in Europe nowadays and are directly related to core issues of the Renewed Lisbon Strategy, i.e, Health and Environment, respectively. Combining these technologies in a new supra-discipline of cluster-based nanotechnology will allow CATSENSE to contribute to the challenges that nanotechnology is now facing in Europe: a poor commercialization track record of new discoveries and a shortage of adequately trained professionals. The training program will deliver nanotechnology experts corresponding to the need of the job market through a multi-level interdisciplinary and intersectorial network. The balanced programme combines local expert training by academia and industrial partners, a network-wide secondment scheme, and a dense seminar, workshop and school schedule.

Partners:

KU LEUVEN, Belgium; UNIVERSITY OF BIRMINGHAM, United Kingdom; TECHNICAL UNIVERSITY OF DENMARK, Denmark; UNIVERSITY OF MILANOBICOCCA, Italy; TEL AVIV UNIVERSITY, Israel; UNIVERSITY OF MILAN; Italy

- **Catalytic Partial Oxidation of Bio Gas and Reforming of Pyrolysis Oil (Bio Oil) for an Autothermal Synthesis Gas Production and Conversion into Fuels (BIOGO)**

Funded By: EUROPEAN COMMISSION, DIRECTORATE-GENERAL FOR RESEARCH & INNOVATION, FP7-NMP-2013 -LARGE-7
Period: 2013-2017

BIO-GO-For-Production is a Large Scale Collaborative Research Project that aims to achieve a step change in the application of nanocatalysis to sustainable energy production through an integrated, coherent and holistic approach utilizing novel heterogeneous nanoparticulate catalysts in fuel syntheses. BIO-GO researches and develops advanced nanocatalysts, which are allied with advanced reactor concepts to realise modular, highly efficient, integrated processes for the production of fuels from renewable bio-oils and biogas. Principal objectives are to develop new designs, preparation routes and methods of coating nanocatalysts on innovative micro-structured reactor designs, enabling compact, integrated catalytic reactor systems that exploit fully the special properties of nanocatalysts to improve process efficiency through intensification. An important aim is to reduce the dependence on precious metals and rare earths. Catalyst development is underpinned by modelling, kinetic and in-situ studies, and is validated by extended laboratory runs of biogas and bio-oil reforming, methanol synthesis and gasoline production to benchmark performance against current commercial catalysts.

Partners:
INSTITUT FUER MIKROTECHNIK MAINZ GMBH IMM, Germany; TOTAL S.A. , France; C-TECH INNOVATION LIMITED, United Kingdom; SPIKE RENEWABLES SRL, Italy; MICROINNOVA ENGINEERING GMBH, Austria; TECHNISCHE UNIVERSITEIT EINDHOVEN, Netherlands; THE UNIVERSITY OF WARWICK, United Kingdom; BRUNEL UNIVERSITY, United Kingdom; TVER TECHNICAL UNIVERSITY, Russian Federation; THE QUEEN'S UNIVERSITY OF BELFAST, United Kingdom; A.N. NESMEYANOV INSTITUTE OF ORGANOELEMENT COMPOUNDS OF RUSSIAN ACADEMY OF SCIENCES, Russian Federation; RUHR-UNIVERSITAET BOCHUM, Germany; BORESKOV INSTITUTE OF CATALYSIS, SIBERIAN BRANCH OF RUSSIAN ACADEMY OF SCIENCES, Russian Federation; UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK, Ireland

- **Steel Coatings For Reducing Degradation in SOFC (SCOReD2.0)**

Funded By: EUROPEAN COMMISSION, SEVENTH FRAMEWORK PROGRAMME, Component and sub-system cost and reliability improvement for critical path items in stationary power and CHP fuel cell systems, SP1-JTI-FCH.2012.3.4
Period: 2013-2016

The economic viability and market place entry of SOFC power systems is directly dependent on their longevity and production costs. Adequate operational life spans can only be achieved, if the performance degradation of the SOFC stacks and Balance of Plant

components over time can be considerably reduced. At the same time, manufacturing costs have to be lowered dramatically for the specifically necessary components securing the long component service life.
The project proposed here aims to further elaborate on the production of coated steel components showing markedly improved properties with regard to chromium release, electrical resistivity and scale growth. The focus of ScoReD 2:0 will be on choosing optimised combinations of protective layer materials with different steel qualities (including low-cost options) and analysing the influence, practicality and cost of different methods of coating. Also in understanding which factors influence the efficacy of such coatings.

Partners:
The University of Birmingham, United Kingdom; TEKNOLOGIAN TUTKIMUSKESKUS VTT, Finland; ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE, Switzerland; AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, Italy; Turbocoating s.p.a., Italy; SOFCPOWER SPA, Italy;

- DRY DRILLING OF ALUMINIUM ALLOYS (DRY Drying)

Funded By: Supply Chain Technology Development Projects, , NATEP, UK
Period: 2013-2016

Adaptation of cutting tools to perform operations without the requirement of lubrication. This will be achieved with the addition of new developed coatings (building on previous research) in conjunction with new design cutting tools. The use of a dry drilling approach for the in-situ, semi-automated drilling of through-holes in aluminium aero-structures is widely regarded as the way forward to address a major Health & Safety issue surrounding atmospheric lubricant particles, which are a significant health risk factor by inhalation & create a slip & fall safety risk by accumulation on surrounding surfaces. Cleaning of lubricant residue also adds cost. The challenge is to maintain machining quality and tool longevity in the absence of external lubricant. The “on structure” nature of the drilling process and the essential portability of the semi-automated tooling prevent the adoption of conventional MQL approaches. Alternative lubricants with improved dissipation characteristics and currently available commercial tool coatings have failed to achieve desired process and product targets, as have conventional self-lubrication tool coatings. This project exploits fundamental knowledge of drilling processes and materials, and combines start of the art capabilities in drill design and modified, high performance PVD coatings, with end user engagement.

Partners:
Kyocera Unimerco Tooling Limited, UK; The University of Manchester, UK

- **Modelling of Magnetron Sputtering for High Value Manufacturing (MOMS4HVM)**

Funded By: UK, Technology Strategy Board, Towards Zero Prototyping
Period: 2014-2016

MOMS4HVM extends the application envelope of modified steady state electromagnetic modelling for the efficient & accurate prediction of industrial magnetron deposition systems. The project will determine & mitigate the limitations of the approach, when compared to more traditional, resource-heavy hybrid particle & hydro-dynamic models,

where complex fluid flow equations have to be solved. This industrially led project's outcomes will be generically extendable to a range of current industrial deposition equipment, itself applicable in multiple HVM markets. Such equipment addresses the needs of lead customers of the UK's advanced surface engineering sector. MOMS4HVM will reduce development times, eliminating the need for extensive proto-typing activities, at multiple levels, including: prediction of coating distribution & functionality on complex industrial parts; efficient transfer of the magnetron coating process for a given range of parts across different coating equipment; design of next generation coating equipment; & optimised in-batch fixtures & composition for the coating of multiple components. It will create new market demand for advanced modelling software.

Partners:
Cobham CTS, UK; The Open University, UK

- **Flexible ITO-Free transparent low-cost substrate with hIgh quality barrier layers (Flexibilis)**

Funded By: EU, OLAE+ Call (Organic and Large Area Electronics)
Period: 2013-2016

FLEXIBILIS will therefore cover these key issues and challenges, by investigating and developing low-cost flexible substrates with novel high quality barriers as well as TCOs (supported by metal grids), deposited by inline capable Physical Vapour Deposition (PVD) or plasma-enhanced chemical vapour deposition (PECVD) methods for industrially scalable production. The project will demonstrate large-area OLED - and OPV - based devices utilising the newly developed substrates, barrier layers and TCOs. With clear exploitation routes for barrier films and TCOs in OLED and OPV, FLEXIBILIS will enable broad commercial benefits across the European OLAE technology markets.

Partners:
The Centre for Process Innovation Ltd (CPI), UK; University of Bolton (BOL),UK; NanoTecCenter Weiz Forschungsgesellschaft mbH (NTCW), Austria; High Tech Coatings GmbH (Miba Coating Group) (HTC), Austria

- Super Rate Elemental & Alloy Cluster Technology - SuperREACT

Funded By: UK, Technology Strategy Board, Technology Inspired CR&D-Nanotechnology
Period: 2013-2016

SuperREACT builds on previous Technology Programme breakthrough research which has established the feasibility of elemental and alloy size-selected nanocluster technology. This project's objectives are truly ambitious: transforming a state-of-the-art research apparatus into a true manufacturing tool, moving from micro-g/day to g/day capability, with the ultimate potential to achieve kg quantities of nanoclusters, which would open up manufacturing opportunities in catalytic, fine chemical, electronic /photonic, bio-medicine, anti-microbials, etc. Clusterbeam condensation of nano-clusters is inherently "clean" and, using multiple elemental sources, flexible in terms of cluster composition and structure. The novel matrix assembly-clusterisation processing developed in SuperREACT will enable continuous production of elemental, alloy and core-shell structures. The University of Birmingham is

contributing its new IPR and the industrial partners their high value manufacturing and end use expertise.

Partners:
Johnson Matthey plc, UK; The University of Birmingham, UK

- **Novel Materials and System Design For Low Cost, Efficient and Durable PEM Electrolysers (NOVEL)**:

Funded by: EU: Fuel Cells and Hydrogen Joint Undertaking (FCH JU), EU.
Period: 2012-2016

The main objective of NOVEL is to develop and demonstrate an efficient and durable PEM electrolyser to produce hydrogen from water, with innovative materials, stack and system design. Electrolysers are in ever increasing demand, for example to convert the variable output of renewable energy sources, including photovolataics and wind power, into a readily transportable and storable fuel, such as hydrogen, which can, for example, be injected into the existing natural gas grid.
By developing new membrane, catalyst materials and new coatings for bipolar plates and current collectors in the novel stack and system design, the project has set performance targets at : Efficiency >75% (LHV); stack cost < €5,000 / Nm3h-1 and Life time >40,000 h.

Project Partners:
SINTEF, Norway; CEA (Commissariat à l'énergie atomique et aux énergies alternatives), France; Paul Scherrer Institute (PSI), Switzerland; Helion SAS, France; Fraunhofer ISE, Germany; Johnson Matthey Fuel Cells Ltd., UK; Beneq Oy, Finland

- **Stable and Low Cost Manufactured Biploar Plates for PEM Fuel Cells (STAMPEM)**:

Funded by: EU: Fuel Cells and Hydrogen Joint Undertaking (FCH JU),
Period: 2012-2016

The European Strategic Energy Technology (SET) Plan has identified fuel cells and hydrogen among the technologies needed for Europe to meet the energy efficiency targets for 2020 as well as to realise the long-term vision for 2050 towards decarbonisation. Correspondingly, the FCH JU program, and more specifically the Application Area "Transportation & Refuelling Infrastructure", aims to pave the road towards the market introduction of fuel cell vehicles.
The concept of STAMPEM is to combine world leading industrial actors with research institutions with the required generic competence capable of providing breakthrough solutions with respect to a new generation coating for low cost metallic bipolar plates (BPPs). By involving an end user of the BPPs developed in the STAMPEM project, the results will be thoroughly verified under realistic operating conditions in a PEMFC stack.
The main objective of STAMPEM is to develop durable coatings materials for metal BPPs, that can be mass produced for less than 2.5 € /kW of rated stack power at futureproduction volumes of 500 000 pieces annually. Properties after extrapolated 10 000 hours from accelerated single cell testing shall still be within the AIP specifications. The main parameters are contact resistance (< 25 mohm cm2) and corrosion resistance (< 10 µA/cm2).

Project Partners:
Stiftelsen SINTEF, Norway; ElrinKlinger AG, Germany; Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V, Germany; The University of Birmingham, UK; Fronius International GmbH, Austria

- Disconnecting Microbes From Food and Beverage Process Surfaces (Disconnecting):

Funded by: The Technology Strategy Board and Tekes, the Finnish Funding Agency for Technology and Innovation

Cleaning is a major cost to the food and beverage industry in terms of production stopages, labour and consumption of energy, water and chemicals. At the same time environmental demands require reduction in water consumption and the use of more environmentally friendly chemicals. To be able to fulfil both economic and environmental requirements, the industry needs novel means for managing microbes on process surfaces. Photocatalytic and low surface energy coatings have been shown to have potential for reducing the attachment of microbial cells to surfaces with reductions of 10-90 % observed, but the results are not always consistent. In addition, most studies have only been carried out using single bacterial species, which does not reflect the real situation. Another means to improve process hygiene could be interfering with microbial signalling. Microbes have been shown to use quorum sensing signalling in forming biofilms, and compounds disturbing quorum sensing have been identified.
The aim of this project is:

- To develop functional material solutions capable of reducing microbial attachment in the food and beverage industries
- To investigate ways to inhibit quorum sensing signalling of microbes when forming biofilms.
- To combine cleaning protocols with novel material solutions and quorum sensing inhibition in order to prevent attachment, and to improve their removal.

Project partners:

- VTT Technical Research Centre of Finland
- Tampere University of Technology, Finland
- Millidyne Oy, Finland
- Panimolaboratorio, Finland
- Cristal Global, UK
- Manchester Metropolitan University, UK

- **Nanocrystalline Water Splitting Photodiodes II, Device Engineering, Integration and Scale-up (WaSp):**

Funded by: Technology Strategy Board, UK

This applied research project WaSp [3] represents the second stage in a programme to produce hydrogen by using solar radiation to photocatalytically split water. The concept was proven by the academic partners, using small laboratory prototype water splitting diodes in the 1st stage of the programme [4]. The current project is focused on the fabrication and commercialisation of an efficient, durable metal-based roof product, to demonstrate

feasibility of direct photo-catalytic water splitting to produce hydrogen in both domestic and industrial roofs.
Solar energy has the capability to satisfy global energy demands. Although the conversion of solar to electrical energy using photovoltaic devices is well-established, electrical energy is not easy to store in large amounts and solar energy is diurnal and intermittent. There is therefore a real need for an efficient (ultimately > 10%), inexpensive (< £5 per m2) solar energy conversion device that generates a readily utilised chemical fuel, which can be readily stored or transported and is non-polluting when used as a fuel.
In this project multiple parallel process innovations (sol-gel; plasma spray/cold spray/solution spray; reactive sputtering) are being investigated to significantly improve technical and commercial performance (including efficiency, scalability, manufacturability and product life cycle considerations). The most promising technological approaches will be incorporated into a functioning demonstrator in a representative environment. The efficiency target of the project is to capture the equivalent of 5% of the solar insolation energy.
Project partners:

- Tata Steel, UK
- Queen's University of Belfast (QUB), UK
- University College London (UCL), UK
- TWI, UK

- **Coated Metal Hydrides for Energy Storage Applications**:

Funded by: The Technology Strategy Board, UK

Hydrogen is accepted as an integral part of the move towards clean, sustainable energy systems. One of the main issues yet to be resolved in a commercially viable way is that of gas storage. The safest option is the use of solid hydrides that can absorb and release hydrogen on demand. However, storage systems must combine optimum gas kinetics with the practicalities of system manufacturing. Thus, while the move towards high surface to volume nano-particulates appears attractive, handling and containing these materials presents enormous difficulties. An alternative approach is based on the concept that, for Mg (high T) and FeTi (low T) hydrides, coated large particles aid kinetics and require no activation. Larger particles allow good fluidisation of the beds aiding permeation and the coatings meant that they could be handled safely in air. The project aims to build on this technology by integrating other hydrides, catalysts and conducting fillers into the powders to address specific requirements (e.g. kinetics) by providing diffusion pathways and improved thermal conductivity. This will result in innovative advanced materials that can be tested on real systems. There is a wide range of potential applications for the developed technology; initial applications are in static energy storage systems. It is intended to demonstrate the technology by utilising it in: (1) the exothermic-endothermic hydrogenation-dehydrogenation cycle as a heat store for concentrated solar power and (2) domestic heat stores, (3) static hydrogen storage for capturing excess electricity generation.
Project partners:

- Eminate Ltd (Lead Partner), UK
- Sunamp Ltd, UK
- ITM Power Ltd, UK
- E.ON, UK
- University of Nottingham, UK

➢ Low Cost, Long Life Photovoltaics

Funded by: The Technology Strategy Board, UK
Aim of the project: To develop low cost, long life, high efficiency photovoltaic cells, based on doped TiO_2 materials. The project led by Teer Coatings Ltd, built on the University of Bolton's unique capability in materials modeling, combined with device design and fabrication. Teer Coatings researched the reactive magnetron sputtering of the doped metal oxides, with the potential for industrial scale up. Optical and electronic properties of the materials were evaluated by Hubei University, China through their partnership with the University of Bolton.
Project Partners:

- The University of Bolton

➢ Nano-Engineered Platinum Catalyst Layers For Fuel Cells (NECLASS)

Funded by: The Technology Strategy Board, UK
Aim of the project: To create new platinum based catalyst layer designs for fuel cells. Novel micro- and nano-structured materials were developed to enable a significantly increased oxygen reduction mass activity of platinum within the fuel cell catalyst layers.
Project Partners:

- Johnson Matthey Fuel Cells Ltd(lead), UK
- Qudos Technology Ltd., UK
- Thomas Swan & Co. Ltd., UK

➢ Production Systems For Value Added Cluster Technology (PROSVACT)

Funded by: The Technology Strategy Board, UK
Aim of the project: To develop vacuum deposition technology for the creation of alloy and core shell atomic and nano clusters at high rates, and the evaluation of deposited clusters in bio- and catalytic applications. Teer Coatings Ltd led this project.
Project Partners:

- The University of Birmingham, UK
- Inanovate (UK) Limited, UK
- Johnson Matthey plc, UK

➢ HydroGEN

Funded by: The Technology Strategy Board
Aim of the project: To develop novel alkaline electrolyser systems to further reduce the cost of electrolysers and improve the economics of the production of hydrogen via electrolysis. Teer Coatings Ltd researched vacuum deposition of non-precious metal catalysts for increased activity and reduced cost.
Project Partners:

- ITM Power plc (Lead), UK
- Pera, UK
- The University of Southampton, UK
- Boddingtons Technical Plastics Ltd., UK

➢ Extended Life Microtooling By Advanced Coating Technology (ELMACT)

Funded by: The Technology Strategy Board and the EPSRC, UK
Aim of the project: To extend the life and enabling the re-use of microtooling through the use of advanced surface treatments and coatings. Teer Coatings Ltd. led the ELMACT project.
Project Partners:

- The University of Manchester, UK
- Rainford Precision, UK
- GF AgieCharmilles, UK
- Rolls Royce plc, UK
- Microsystems UK Limited, UK

➢ AMBIO: Advanced Nanostructured Surfaces For The Control Of Biofouling

Funded by: European Commission through its 6th Framework programme, EU
The aim of AMBIO was to provide a combination of fundamental and application-oriented research that would lead to the development of novel antibiofouling coatings which work through their physico-chemical properties rather than the release of biocides. Teer Coatings Ltd.'s involvement in the project resulted in the successful development of fouling resistant siloxane coatings using PACVD. Underwater optical windows coated with the Teer Coatings Ltd. coating showed a 25-50 % reduction of biofouling compared to uncoated windows which meant that the period over which useful data could be collected increased from a few days (control, uncoated) to approximately 3 weeks [2].
Project Partners:

- University of Birmingham, UK
- INPL/CNRS, France
- TNO, Netherlands
- University of Pisa, Italy
- International Paint Ltd (an Akzo-Nobel company), UK
- Gebze Institute of Technology, Turkey
- University of Mons-Hainaut, Belgium
- CIDETEC, Spain
- Linkoping University, Sweden
- University of Newcastle, UK
- Institute of Metals and Technology, Slovenia
- Polymer Laboratories Ltd, UK
- Institut fur Polymerforschung, Germany
- University of Heidelberg, Germany
- BioLocus A/S, Denmark
- Zenon Manufacturing and Services, Hungary
- KIMAB, Sweden
- Centrum Techniki Okretowej Spolka Akcyjna (Ship Design and Research Centre), Poland
- Argus Chemicals srl, Italy
- Laviosa Chemica Mineraria, Italy
- Wallenius Marine, Sweden
- KEMA Nederland BV, Netherlands
- OCN, Netherlands
- BASF Aktiengesellschaft, Germany
- Val VGS, Norway
- Nanocyl SA, France

- Technion, Israel

➢ ACTIVATION: Super High Energy Milling In The Production Of Hard Alloys, Ceramic and Composite Materials

Funded by: European commission – Specific Targeted Research Projects (STRP), EU
Aim of the project: The development and design of new super high-energy planetary mills; To study the fundamental aspects of mechanical activation; The development of new materials with improved performance; The development of high volumes production of nano-scale high performance materials at low cost; The development of technologies of recycling solid materials; Investigation of powders and materials produced in a full scale technological line.

➢ Coatings for Improved Performance of Cutting Tools Used for the Machining of Titanium Alloys

Funded by: UK DTI through Knowledge Transfer Partnership
The aims of the project:

- To develop a range of successful coatings for the machining of titanium alloys and to introduce them into the aircraft industry.
- To develop a fundamental understanding of the properties that make a successful coating for specific applications.
- To study the machining conditions, feed rate and speed and amount and type of lubrication for titanium alloys and to establish a database of optimum conditions.

Project partner:

- Warwick University, UK

➢ Development of Non-Stick Coatings for Polymer Processing

Funded by: UK DTI through Knowledge Transfer Partnership
The aims of the project:

- To develop coatings for polymer processing tools to prevent/reduce fouling of the tools.
- To develop appropriate test methods to evaluate the coatings for polymer processing.

Project partner:

- Loughborough University, UK

➢ Improving Competitiveness and Conserving The Environment Through High Durability Nanocomposite Coatings (Hidur)

➢ **Funded by:** European FP5-GROWTH

Fuel efficiencies and CO2 emission reductions for ground based transportation can be made by improving the wear resistance of aluminium alloys. Available surface protection

treatments for aluminium and steel auto-engine components were becoming increasingly inadequate because of recent changes in lubricating oils. A related problem was the need to extend the service life of gears used in wind turbine generators, to assure sustained power generation. The project aimed to address these problems through the creation of exceptionally wear resistant nanocomposite coating materials. Plasma based coating technologies were exploited due to an existing over reliance on “wet” deposition technologies, like electroplating and electro less deposition, which have undesirable environmental impact [2].

Project partners:

- University of Leeds, UK
- Universität Gesanthochschule Siegen, Germany
- Università di Lecce, Italy
- Tampere University of Technology, Finland
- Greenhey Engineering Services, UK
- Rolls-Royce & Bentley Motor Cars Ltd, UK
- Federal Mogul Burscheid, Germany
- Federal Mogul Wiesbaden, Germany
- SMEI Salentina Meccanica Industriale, Italy

➢ Developing an appropriate drilling test to represent the performance of PVD coatings deposited on cutting tools.

Funded by: UK DTI through Knowledge Transfer Partnership

The aims of the project were:

- To improve tool life by applying hard and soft PVD coatings through detailed analysis of tool wear, cutting forces, and surface roughness of the machined parts when cutting difficult materials such as highly alloyed steels.
- To obtain economical benefits through elimination/reduction of cutting fluid and lubricant costs, achieving longer tool life and less tool maintenance, improving quality of machined parts as well as elimination of indirect costs such as cleaning cost and waste disposal.

Project partner:

- Warwick University, UK

➢ Hybrid: Rapid and Low Cost Deposition of Coatings Through A Novel Hybrid Plasma Source

Funded by: European FP5-GROWTH

This project aimed to reduce the costs of PVD coating and so enable wider take-up of this technology in general, specifically tackling the need for low cost, high quality coatings in:

- The production of enhanced wear resistant coatings for tooling in the aircraft industry;
- The deposition of low friction coatings for automotive engine parts;
- The improvement of binding procedures in diamond grinding wheels;
- The application of decorative coatings on taps, mobile phones and door handles etc.

In an attempt to achieve this, novel hybrid plasma sources for the deposition of very high quality coatings at very high rates both under vacuum and at atmospheric pressure were developed. Evaluation and testing of the hybrid plasma sources and coatings deposited by them was undertaken.

Project partners:

• Enterprise Ireland

• Uppsala University, Sweden
• Airbus, Spain
• Centro Ricerche Fiat, Italy
• DWH, Germany

➢ ISOTECH: Deployment of In-Situ Optical Monitoring Techniques for Tailoring Thin Film Properties for Specific Advanced Industrial Applications

Funded by: European Framework Programme

The Isotech project was initiated by the demand from manufacturers of razor and industrial blades, bearings and seals, and piezoelectric quartz oscillators for improved product and component performance via the use of thin film surface coatings. Optimisation of these coating properties may be attained through in-situ, (during film growth), monitoring of their stoichiometry, composition, microstructure and thickness. For the purpose of in-situ monitoring of the coating during deposition, a low-cost, high-speed spectroscopic ellipsometer was developed within the project and further improved into a commercially available instrument with distinct competitive advantages.

➢ REMAST: A Certified Reference Material for the Scratch Test

Funded by: European Framework Programme
The Remast project was aimed at the development of a certified reference material (CRM) as a means of controlling the proper functioning of a scratch test instrument. The technical work involved obtaining a CRM for the scratch test. The work included a feasibility study, during which the feasibility of two candidate real world reference materials, titanium nitride (TiN) and diamond like carbon (DLC) coatings on a high speed steel substrate were evaluated. After mid-term, the selected material (DLC) was certified following the standard BCR procedures. In addition, a considerable effort was devoted to improving the scratch stylus manufacturing process. A workshop on the development and standardisation of test methods for engineering coatings was also organised.

MAGPLAT: Magnesium Plating and Assembly for Advanced Applications

Funded by: European Framework Programme
This project was aimed at developing environmentally friendly coatings/surface treatments for magnesium alloys, to provide corrosion resistance. TCL involvement was aimed at developing conductive coatings required to withstand temperature cycling and moisture tests, or 48/96hrs salt spray, for space and electronic applications.

➢ The Development of Long Life Coated Artificial Hip Joints

Funded by: UK DTI (SMART project)
Graphit-iC™ coatings were applied to CoCrMo test pieces and hip joint couples for wear tests and simulator testing. The reduction in wear rate achieved on wear tests suggests that the life of implanted hip joints could be significantly extended. Further simulator testing is needed at this stage and work was continued via a CASE award and collaboration with

implant manufacturers. Equipment for the deposition of the coating has been scaled up to cope with large batch production and is in daily use for a variety of applications including automotive.

- **ACABONI: Amorphous Carbon-Boron-Nitrogen Coatings for High Temperature Applications in Cutting Tools**

Funded by: European Framework Programme

The project was completed successfully. The sputtered carbon based hard coatings developed (pure carbon or C/Cr) appeared to have much better tribological and wear resistant properties in terms of low wear and low friction under high load conditions. The cutting performance (gear cutting) was better than commercial TiN hard coatings in terms of lower cutting force and higher feed rates.