**Collaboration areas and project descriptions for the UPC and Leeds University Cooperation**

The PhD projects for the first students to come to Leeds in 2018 will be in the following areas

* Nanotechnology
* Biomaterials
* Microfluidics
* Corrosion
* Tribology

Projects may span one or more of the areas above.

Examples of projects that could be submitted for the students to apply for are given below:

***Project 1. Corrosion in supercritical systems; using microelectrode technology to understand localised effects***

Research area(s): corrosion, nanotechnology

Corrosion in supercritical CO2 is relevant to the transport of CO2 for Carbon Capture and Storage and also for Enhanced Oil Recovery. In both cases the presence of impurities (water and other gases) is important and has the ability to promote localised corrosion. Our understanding of localised corrosion is limited and much of this is due to the fact that we struggle to spatially resolve the electrochemical corrosion activity on surfaces. There is a need to understand the link between the local surface environment relating to the wetting of the surface by supercritical CO2 or by the water phase. In this study we will develop electrochemical techniques to understand the local corrosion environment and use this methodology to understand the initiation of pitting corrosion. We will develop a pitting corrosion map (initiation and propagation) for the range of contaminants in supercritical CO2.

**Project 2. Graphene / graphene oxide as a multifunctional material for corrosion film modification to mitigate corrosion**

Research areas: corrosion, nanotechnology

Currently corrosion inhibitors are used to ensure that the material degradation rates are properly controlled. However, some limitations in term of operational constraints, costs and environmental issues need to be considered carefully. It is well known that corrosion product scale formed on the surface can be act as a barrier and providing protection from electrochemical degradation, such as FeCO3. The purpose of this project is to design a new approach for corrosion controlled by modifying the corrosion product scale in the presence of multifunctional nanoparticles. The novel corrosion mitigation approach relies on the modified corrosion layer having lipophilicity as well as accelerating the crystallization and mechanical properties.

***Project 3. Polymer brush layers for optimised aqueous lubrication for medical devices***

Research areas: tribology, nanotechnology, biomaterials

To achieve superlubricity (i.e. ultra low friction coefficients) on metallic devices used in the medical field requires innovative surface engineering. There has been a large amount of work on polymer brushes; they are analogous to natural based lubrication systems where a sugar chain is bound to a protein backbone. Functionalising the head groups enables these to be tethered to surfaces and the lubricity of surfaces can be dramatically altered. In this study we will investigate the superlubricity, and the critical tribological conditions across which this is sustainable, of zwitterionic polymer brushes. These contain positively and negatively charged ion groups. The study will examine the grafting density and the link between this and the tribological performance. We will investigate the feasibility of enhancing the mechanical stability of these layers through incorporation of nanoparticles into the brush layer.

**Project 4. The development of triboelectric nanogenerators (TENGs)**

Research area(s): Nanotechnology, tribology, biomaterials

Triboelectric nano generators (TENGs) are new; they harness the positive aspects of triblogy to generate power. This can be harnessed in a positive way from involuntary movements in the body such as muscle contraction and used to drive medical implants. Battery technology is a great limitation for medical devices and TENGs offer a new way to provide energy locally. We will investigate the triboelectric series in air and in liquid environments and produce a tribology optimisation map for the design of TENG devices.

***Project 5. Electrochemistry of new battery electrode materials based on carbon composites***

Research area(s): nanotechnology, corrosion

Extending the lifetime of portable devices and increasing the mileage of electric vehicles have been in area of many interests to the scientific community. Furthermore, an extensive amount of effort has been devoted to increasing the energy density and lowering the cost of batteries. Much current battery technology is insufficient to meet the long-term needs of modern societies. Carbon composites can be considered as electrodes of rechargeable aqueous batteries and improving dispersion or conductivity. Carbon composites can be widely used as the battery electrodes and have various advantages such as environmentally, abundant, cheap, easy to handle, stage in aqueous solution. The project are study the effects of corrosion inhibitor on the corrosion inhibition and battery performance of the new battery materials. Chemical and electrochemical methods have been used to evaluate the corrosion behavior and inhibitor efficiency. In addition, the performance of this battery in the presence of inhibitor was studied.

***Project 6. In-situ Raman spectroscopy of graphene as a solid lubricant for space applications***

Graphene, one of the typical two-dimensional (2D) materials, has been gaining much attention as a potential solid lubricant owing to its low shear force property, high chemical inertness and extremely good mechanical strength. An important factor to consider for utilization of graphene coatings in practical applications is regarding the cost effectiveness of the coating method. The techniques developed to acquire graphene-based coatings cost effectively include electrophoretic deposition (EPD),inkjet printing,rod coating,and electrodynamic spraying process (ESP). Among these, ESP is considered to be a suitable method for fabricating high quality graphene coatings owing to its various advantages such as simple process, large area deposition capability, coating uniformity and good thickness control. In this project, the superior graphene coating with high wear resistance and low friction behaviours will be developed for actual industrial application. And its lubrication mechanism will be systemically investigated.

***Project 7. In-situ Atomic Force Microscopy for the assessment of protein/surface interactions in medical devices***

Research area(s): tribology, nanotechnology, biomaterials

The use of the AFM as a single asperity tribometer brings insight into the details of surface/environment interactions. One such interaction that requires further study is between proteins in synovial fluid and the surface of Co-based alloys, especially when there is a tribological action and the influence of biotribocorrosion. We will use a methodology developed in Leeds to generate biotribofilms on surfaces of CoCr alloys and assess their kinetics of formation. The study will assess how the complexation of the Co ions and the proteins affects the nature of the surface layer and the implications for achieving low friction and low wear at the surfaces of medical implants.

***Project 8. Hydrogen permeation in Ti alloys as biomaterials***

Research area(s): tribology, corrosion, biomaterials

Hydrogen has been found to be responsible for many mechanical failures of materials across a number of application areas including in biomedical implants. The role of H and its permeation into Ti alloys is still not fully understood. We will use a new Devanathan cell, built to be coupled with a tribometer to assess the role of the sliding action in a tribocorrosion contact on the H production and permeation into various commercial and developmental Ti Alloys. The electrochemical assessment of H permeation in Ti in a tribological contact is new and we will couple this analysis with careful examination of the H in the Ti using gas and mass spectrometry analysis as well as the detection of Ti hydrides or other compounds.

***Project 9. Protective coating strategies for Magnesium and its alloys using plasma vapour deposition processes***

Research area(s): corrosion, tribology

Magnesium is the 8th most abundant element on the planet, possessing some highly advantageous properties that make it an excellent material for a number of applications. Unfortunately, magnesium has a number of undesirable properties, including poor corrosion and wear resistance, hindering its use across automotive and aerospace sectors. One of the most effective ways to prevent corrosion is to coat the substrate in question. This project will focus on the use of novel plasma vapour deposition techniques to engineer uniform, well adhered, low porosity coatings which can be deposited at low temperatures, below the stability temperature of magnesium alloys. The developed coatings will be evaluated in both corrosive and erosive environments to quantify their resistance.

***Project 10. The galvanic effect of magnetite on carbon steel corrosion in the secondary water of pressurised water reactors***

Research area(s): corrosion, nanotechnology

Magnetite (Fe3O4) is a protective oxide layer capable of forming on the inner surface of carbon steel pipework used in the secondary water systems of pressurised water reactors (PWRs). However, these layers are susceptible to local dissolution or removal in turbulent flow regimes. The high electrical conductivity and low band gap of 0.1 eV for magnetite means that it effectively behaves as a metal, potentially supporting electrochemical reactions and creating galvanic cells on the steel surface in the event of local removal of the layer. This project explores the galvanic interactions between magnetite layers and carbon steel in the secondary water systems of PWRs in an effort to better quantify the threat posed to carbon steel pipework used in the nuclear industry.

***Project 11.******Project 10: Load sensing thin films for tribological applications***

Research area(s): tribology, nanotechnology

This project will look into designing and processing PECVD (Plasma Enhanced Chemical Vapour Deposition) thin films with controllable electrical properties. This will allow tuning their load sensing capability by correlating applied mechanical stress with electrical response. The coatings will be manufactured using the state-of-the-art coatings facility available in Leeds, employing the latest thin film technologies including the nano-particles source. Plasma diagnostics tools will be used for deposition process optimisation by linking the plasma composition to the coating’s mechanical and electrical properties.

***Project 12. An experimental and computational methodology for exploring CO2 corrosion in multiphase flow systems***

Research area(s): corrosion

Safe and efficient recovery of hydrocarbons is of paramount importance in the oil and gas industry. One of the main obstacles to successful oil production is internal pipeline corrosion, which can cause catastrophic and unexpected failures, leakages, down-time and severe environmental damage. Although there now exists a good understanding of the CO2 corrosion mechanism in single phase systems, much less is known about the multiphase flows which are encountered in practice where the multiphase flow patterns (stratified, wavy stratified, mixed stratified, annular etc.) influence the corrosion process. Consequently, there is a great demand for predictive tools that can assess CO2 corrosion in multiphase systems. This project adopts a new, combined experimental and computational approach to understand and predict CO2 corrosion in multiphase flows systems. The ultimate goal is to develop accurate and reliable empirical correlations and mechanistic models for mass transfer and diffusion of species which can predict corrosion rate in multiphase flow systems.