EPSRC & SFI Centre for Doctoral Training in Advanced Metallic Systems

PhD in Implementing Dual Phase Texture Development Mechanisms into Methods for Texture Prediction

Supervisors:	Prof. João Quinta da Fonseca
Collaborator:	Rolls Royce
Based at:	The University of Manchester
Stipend:	£17,668 UKRI rate (additional £5,000 per year)
Open to:	UK Nationals only, with a 2.1 or 1st class degree in a STEM discipline

This project is based across both the Department of Materials and is sponsored by Rolls Royce. We are seeking a UK resident with a 2.1 or 1st class degree in a STEM discipline.

Zirconium alloys are key materials in the manufacture of small nuclear powerplants, where they are used for their excellent corrosion resistance and neutronic properties, but also for their excellent strength. These exceptional properties are dependent on the microstructure of the alloys, i.e. the structure at the micrometer scale. This makes manufacturing using strong Zr alloys a major challenge, since as well as achieving the desired final shape, it is crucial that the microstructure of the alloy is controlled during their processing and manufacture.

Because of their high strength, dual-phase Zr alloys are processed at high temperatures, where the microstructure changes continuously through a variety of different mechanisms including crystallographic slip, recrystallization and phase transformation. Although these mechanisms are well understood on their own, their interactions during processing and manufacture make predicting the microstructure at the end of the process very difficult. For example, one of the major microstructural characteristics that needs controlling is the crystallographic texture, which is the crystallographic alignment of the grains in a component. Research has shown that the texture is affected by all these mechanisms and is not purely a consequence of slip induced lattice rotation. To be able to control texture during processing therefore means understanding the relative importance of these different mechanisms. To further add to the complexity, typical industrial processes involve thermal transients and multiple deformation paths, which vary across a component. This produces a very large set of possible conditions which simply cannot all be studied empirically.

In this project we will use statistical methods to combine results from computational modelling, which use our current best understanding of the relevant physical processes and experimental results, both historical and new to develop a framework for predicting textures in dual phase Zr components. The aim is to develop a framework that can be used to make rapid texture predictions during processing and manufacture. Unlike traditional simulation approaches, this data enhanced framework will provide uncertainties alongside the texture predictions, and can be extended as our computational modelling capability and experimental database grow over time.

Alongside statistical modelling, the project offers opportunities to develop skills in physical materials modelling and microstruture characterisation, using electron microscopy and diffraction. The student will join a large group of researchers working on microstructure prediction in Manchester and collaborate with other researchers in the Turing Institute and at manufacturing research centres. The projects include regular meetings with the industrial sponsor and the opportunity to work at Rolls-Royce for short periods.

The project will be carried out at the Materials Performance Centre, part of the Department of Materials and one the centres of the Nuclear Dalton Institute at the University of Manchester. The centre has extensive expertise in microstructural characterization, metallurgy, oxidation, and structural integrity of nuclear components and benefits from the access to state-of-the-art material characterization facilities and autoclaves for replicating nuclear environments via the Henry Royce Institute. The successful candidate will acquire skills in materials performance and will become proficient in the materials and microstructural characterization, which include secondary electron microscopy (SEM), focused ion beam (FIB), transmission electron microscopy (TEM), X-ray diffraction (XRD) and other advanced characterization techniques.