EPSRC & SFI Centre for Doctoral Training in Advanced Metallic Systems

PhD in Microstructure Level Testing using High Resolution Digital Image Correlation.

Supervisors: Prof João Fonseca & Prof Phil Withers
Collaborator: Element Materials Technology
Based at: The University of Manchester
Stipend: UKRI stipend (£15,609 in 2021-22) plus £3,250 per year
Open to: Candidates with a strong degree in a STEM discipline, who will be Eligible to Work in the UK on completion of the PhD.

The Centre for Doctoral Training in Advanced Metallic Systems is a partnership between industry partners and the Universities of Sheffield and Manchester and the I-Form Advanced Manufacturing Centre, Dublin. CDT students undertake a doctorate with an in-depth technical and professional skills training across a structured 4-year programme. For more information on our cohort training programme and our impact from our doctoral research projects with industry please visit www.metallicscdt.co.uk.

This project is based at the University of Machester and is sponsored by Element Materials Technology. It is open to candidates with a strong degree in a STEM discipline, particularly maths, and an interest in simulation. International applications may be considered for candidates with an IELTS standard of 7.0 or higher overall, but they must be Eligible to Work in the UK on completion of the PhD.

The performance of engineering alloys depends on both chemistry and microstructure. Chemistry can be controlled to some extent using materials specifications, but this is more difficult for microstructure. Big microstructural differences can be detected by simple micro-structural triaging using metallography, but alloy performance can be affected by small differences which cannot be easily detected. Instead, engineering companies use extensive testing and fixed processes of manufacture to ensure the microstructure in components meets their requirements.

Although this approach works well, it limits innovation and decreases supply chain flexibility. Once a process of manufacture has been established, it is too costly to change it or even to move it to a different manufacturer. It also slows down the adoption of new processes like additive manufacturing, where the microstructure can vary very markedly within one component and even be different in components and test specimens.

This PhD project aims to demonstrate how these challenges can be addressed by measuring deformation at the micro-structural scale and obtaining unique data that can be used in the certification of new alloys and new manufacturing processes in aerospace, adding value to existing testing approaches. We propose to exploit recent developments in high resolution digital image correlation (HRDIC) at Manchester to measure material deformation directly at the microscale and quantify differences in behaviour between different materials or microstructures. The resulting data can then be used in combination with macroscopic testing results to determine material performance, and in particular to better demonstrate how microstructure affects material performance, information which is of great value to both engineering companies and regulators.

In HRDIC, materials are tested in a scanning electron microscope using a nanoscale gold pattern as fiducial markers. The results are deformation maps with a spatial resolution as high as 100 nm, over areas of several mm. The Royce Institute has a new machine dedicated to this kind of testing (TANIST), which enables relatively high throughput testing, and we have also developed our own open source data analysis software (DefDap) to process the data after testing. Below are a couple of examples of the HRDIC technique applied to nickel superalloys and additive manufactured titanium alloys [1,2].

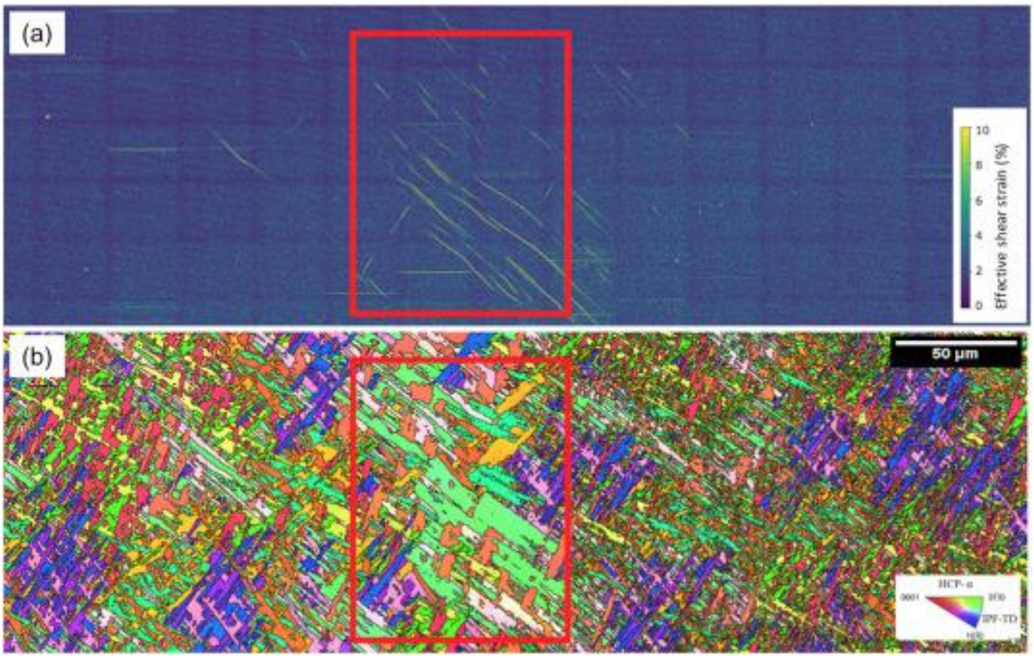

Fig 1: Strain localization map (top) in a wire additive manufactured titanium microstructure (below) show early yield in a microstructural feature produced by the process [2].

For more information please contact Joao Fonseca (joao.fonseca@manchester.ac.uk)

References
1. Harte, Allan, et al. "The effect of solid solution and gamma prime on the deformation modes in Ni-based superalloys." Acta Materialia (2020).https://doi.org/10.1016/j.actamat.2020.04.004
2. Lunt, David, et al. "The effect of loading direction on strain localisation in wire arc additively manufactured Ti–6Al–4V." Materials Science and Engineering: A (2020): 139608.https://doi.org/10.1016/j.msea.2020.139608