Probing the ductile-to-brittle transition (DBT) in BCC fusion materials

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Introduction

Understanding the micromechanics of ferritic steels under irradiation may help us predict the ductile-to-brittle transition (DBT) in BCC fusion materials. Traditional testing of the DBT requires large quantities of material, which are very difficult to obtain in the irradiated condition. In this work, a methodology for studying the micromechanics of irradiated fusion steels is being developed, using small samples and in-situ testing, in order to understand the expected behaviour of BCC fusion metals around the DBT.

Method

High Resolution Digital Image Correlation (HRDIC) has been used extensively to study deformation behaviour in many alloy systems. In this study, the fundamental behaviour of a BCC iron matrix was investigated using HRDIC in interstitial free (IF) steel. HRDIC provides quantitative information about the strain distribution at the microstructural level, which when correlated with EBSD allows the strain behaviour to be linked to the crystallography. The effect of temperature and strain level can be investigated for both irradiated and unirradiated material. The same methodology can be applied in future to more complex reduced activation ferritic martensitic (RAFM) fusion steels, to give insight into the expected deformation behaviour under fusion conditions.

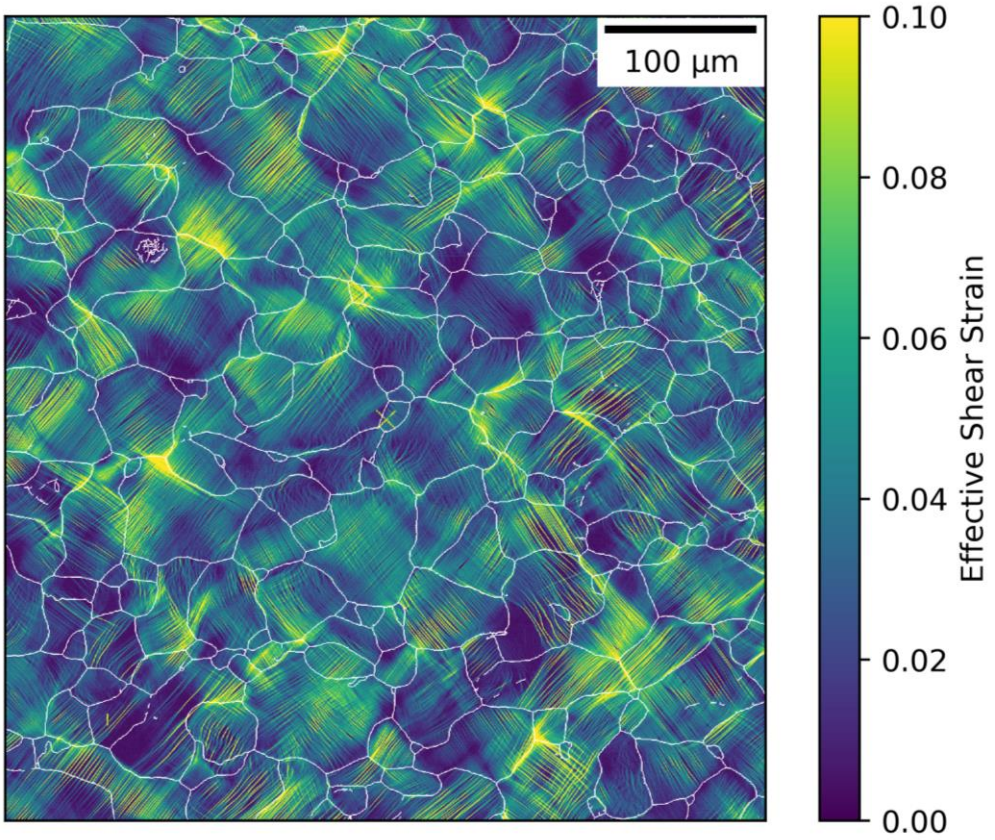

Figure 1: HRDIC Strain distribution map showing effective shear strain in IF Steel, with EBSD of the same area superimposed using DefDAP [1].

Summary

This work will present the initial results from experiments using HRDIC to study the deformation effects at temperatures down to cryogenic conditions, along with the challenges associated. Comparison to HRDIC performed on proton irradiated material will also be presented. This shows great promise for developing greater understanding of the ductile-to-brittle transition in BCC fusion materials, and for improving our ability to predict it in different alloy systems.

References

[1] Atkinson, Michael D, Thomas, Rhys, Harte, Allan, Crowther, Peter, & Quinta da Fonseca, João. (2020, May 4). DefDAP: Deformation Data Analysis in Python - v0.92 (Version 0.92). Zenodo.