Radiation Damage with a Twist: A study of helical dislocations in neutron irradiated FeCr alloys

Haley, J.[1], Odette, G.R.[2], Lozano-Perez, S.[1] and Roberts, S.[1]

[1] University of Oxford, United Kingdom, [2] University of Cailifornia Santa Barbara, United States

Network dislocations within nuclear steels can greatly affect the spatial distribution of irradiation induced defects. Particularly, in neutron irradiated Ferritic/Martensitic steels, dislocation loops are frequently observed preferentially in the vicinity of dislocations, but there is not an agreed consensus behind why this is so.

Here we have revealed the process behind how dislocations in BCC FeCr alloys cause local clustering of dislocation loops. Specifically, we have shown how defects interacting with pre-existing screw dislocations cause the formation of mixed screw-edge helical dislocations. Helical dislocations are frequently observed in rapidly quenched metals, due to the super-saturation of vacancies causing screw dislocations to climb radially. Their observation in irradiated microstructures is not new, but they are rarely acknowledged or discussed in detail. It has been frequently assumed that interstitial type defects are responsible for creating helical dislocations due to their higher mobility in these metals than vacancies.

For the first time, we have used a combined *electron beam-precession* and *weak-beam dark field* technique to reveal with clarity the shape of these helical dislocations in a neutron irradiated Fe9Cr alloy. Additionally, through inside-outside contrast analysis, we have revealed that the formation of these helical dislocations is vacancy driven, not interstitial.

With the knowledge that dislocations in these materials act as vacancy-biased sinks, we have shown that the origin of heterogeneously distributed irradiation induced defects must be a result of the interstitial-biased defect population, since vacancy defects are removed from the local microstructure by the dislocations.

After irradiating these materials *in-situ* with TEM, we will reveal the rate at which these structures form, with an aim to improve our understanding of the role that the relatively immobile vacancies have on the visible microstructural damage, and ultimately the macroscopic hardening.