HENRY ROYCE INSTITUTE

UNIVERSITY OF OXFORD

Department of Materials

CASE STUDY: ATOM PROBE

Understanding irradiation-induced nanoprecipitation in zirconium alloys

Researchers combined three methods of characterisation at different scales

This approach enabled an improved understanding of the effects of proton irradiation on the zirconium alloys commonly used in the cladding and structural components of reactor cores.

Iron and chromium-rich rod-like formations were observed in a zirconium alloy (Zircaloy-2), following proton irradiation. Correlative analysis in Atom Probe Tomography, electron diffraction and scanning transmission electron microscopy, and energy dispersive X-ray (STEM-EDX) revealed the rod morphology, crystallography, dimensions and composition. There was good agreement between all three techniques. [1]

Atom Probe Tomography showed that the atomic ratio of iron and chromium in these rods increased at distances greater than ~200nm from the closest partially-dissolved $Zr(Fe,Cr)_2$ second phase particles. This suggested that rods nucleate as a result of the irradiation-induced dissolution of pre-existing intermetallic phases. It also indicates that the chemical composition of the rods depends on the relative diffusivities of iron and chromium in the α-zirconium matrix.

This research has implications for irradiation-induced growth and hardening in zirconium alloys. It offers a unique insight into the nanoscale irradiation response of these materials. This understanding is vital in predicting future performance - and assists with future alloy design.

Lead contact: Dr Paul Bagot

[1] Contract research collaboration between Universities of Manchester and Oxford
Journal of Nuclear Materials, 510 (2018), 460-471