Helium Bubble Behaviour in a Lattice-Damaged FCC Metal

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Further knowledge of helium bubble formation and mobility within lattice-damaged fcc metals is required to understand and predict the properties of plutonium and its alloys for safe-handling, use, and long-term storage. Self-irradiation within plutonium metal results in lattice damage, compositional changes, and helium accumulation at a rate of 41 appm/year due to α-decay. These phenomena are thought to affect the materials mechanical properties and corrosion behaviour.

In the absence of α-emitting material, surrogate metals with the same crystal structure (fcc) for example palladium can be subjected to radiation effects such as helium ion implantation. This study investigates helium bubble formation and mobility within this metal using experimental techniques to gain further understanding of these effects. Experimental techniques include electron microscopy, EELS, and mechanical tests to determine bubble locations, sizes, densities, and distributions over a range of implanted helium ion dose to simulate different ages of plutonium.

Helium implantations to a range of doses were performed using the 5 MV tandem Pelletron ion accelerator at the Dalton Cumbrian Facility (DCF). TEM was used to image the bubbles to measure their sizes, and to observe their locations and growth during heating experiments. Preliminary results reveal that helium bubbles exist over a range of different sizes within the metal and were found to have an average diameter of 1.70 nm which is in agreement with the sizes of helium bubbles seen within plutonium by Schwartz and Wall (Schwartz et al. 2003), and that ion implantation produces unusual effects upon the microstructure. EEL spectroscopy will be used to determine the atom number density within the bubbles following a procedure used to determine bubble densities in steels (Fréchard et al. 2009).

References

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