

He bubble nucleation and growth rates in naturally aged δ -Plutonium

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The self-irradiation through α -decay in Pu-Ga alloys remains an outstanding issue as the development of He bubbles through this decay negatively affects the mechanical properties of these alloys. Both experimental and modeling studies have quantified changes in Pu-Ga mechanical properties, but they require knowledge of He bubble development with respect to time. Previous studies show that He atoms are generated at an approximate rate of 41 at ppm/yr¹, and He bubble number densities from 0.6-2.0x10¹⁷ cm⁻³ are associated with this generation rate². However, this rate has not yet been used to predict He bubble number densities in samples older than 42 years².

Recent studies using scanning transmission electron microscopy have provided new He bubble sizes and distributions in three naturally aged Pu-Ga alloy samples^{3,4}. Here we apply kinetic models, including crystal growth rate⁵ and crystal size distribution (CSD)⁶ equations to assess He bubble development as a function of time. CSD calculations for He bubble size distributions are found to be within the range of previously published He bubble number densities², suggesting the viability of applying CSD equations to He bubbles. Based on over 1,100 He bubble measurements from the three aged samples, we calculate nucleation and growth rates to provide realistic forecasting on He bubble growth rates, as well as bubble size and abundance in older Pu-Ga alloys.

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