Progress of helium evolution in aging titanium tritide film

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The generation and accumulation of ^{3}He by tritium decay modified the physical and chemical properties of tritides. Here helium release from titanium tritide films at room temperature also have been studied, and the result shows early in life nearly 100% of the ^{3}He is retained in the lattice and as a critical concentration (He/Ti ~0.25 to 0.28) is reached the lattice will no longer retain the ^{3}He, and it is emitted at about the generation rate. The evolution of lattice defects in long-aged titanium tritide films is investigated by X-ray diffraction (XRD) over a period of about 1600 days (>4 years). The result reveals three main changes of lattice parameter occurring during aging and an hkl-dependent unit-cell changes. The thermal desorption (TD) has been used to investigate the ^{3}He release from titanium tritide film with ^{3}He/Ti atom ratio from 0.006 to 0.325. Below 1300K in ^{3}He desorption spectra there are four kinds of peaks that account for different states of helium in aging titanium tritide, e.g. ^{3}He bubbles punching up to the surface, ^{3}He bubbles and He cluster.

Results of XRD, TD and helium release were synthesized. And efforts have been expended to explaining why at low concentraions the ^{3}He is retained and why above critical concentration it suddenly is no longer retained. A continuum-scale evolutionary model of helium for aging titanium tritide film is described which accounts for major features of the tritide experiment data: ^{3}He/Ti$\leq$0.003, the formation of isolated tetrahedral interstitial ^{3}He atoms or ^{3}He clusters; 0.003$\leq$^{3}He/Ti$\leq$0.006, interstitial ^{3}He atoms diffusion into (111) planes and precipitate into clusters, then spontaneous form Frenkel pairs; 0.006$\leq$^{3}He/Ti$\leq$0.023 platelet helium bubbles growth by dislocation dipoles expansion; 0.023$\leq$^{3}He/Ti$\leq$0.052 the transition from platelet bubbles to sphere bubbles by loop emission; ^{3}He/Ti$\geq$0.052 sphere bubbles growth by dislocation loop-punching. The combined stress-assisted-block loop punching growth for random bubble arrays and an average ligament stress criterion predicts an onset of inter-bubble fracture in good agreement with the He/Ti ratio observed for rapid He release. Fundamental knowledge of titanium tritide was obtained through these models. Foundational techniques would also be used to study the aging effects of other metal tritides.

Select fields and topics: Ⅱ-6

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