Effect of Implantation and Annealing Schedule on Helium Retention in Tungsten

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Implantation of helium in metals and alloys under fusion irradiation conditions gives rise to a serious concern regarding the performance and lifetime of materials used in the structural components of a commercial fusion reactor. This concern stems from the considerations that at elevated temperatures the continuous helium implantation may enhance swelling, grain boundary embrittlement, blistering and so on. In an inertial fusion energy chamber the first wall will be subjected to different ion fluxes, including helium. Moreover the first wall is expected to reach $\sim$2500°C after each pulse. Thus, helium accumulation will proceed in a form of pulsed implantation and annealing. To understand the helium retention characteristics and helium bubble evolution in tungsten under pulsed conditions, single crystal and polycrystalline tungsten were implanted at 850°C with 1.3 MeV $^3$He up to $10^{19}$ He/m$^2$ and flash annealed at 2000°C while varying the number of implantation/annealing cycles [1]. It was found that helium retention strongly depends on the cycle number and duration of the irradiation and annealing. In order to establish a proper understanding of helium accumulation under implantation/annealing cycle conditions, detailed numerical calculations based on a twodimensional kinetic equation describing the size distribution function of helium-vacancy clusters have been carried out. A newly developed grouping method has been used to integrate the kinetic equation. Calculations have been carried out taking into account diffusion of atomic He via the interstitial mechanism, SIA-He replacement mechanism and thermal evaporation of He from He-vacancy clusters. The calculated results are found to be in good accord with experimental results.

1. Hashimoto et al., Fusion Science and Technology 47 (2005) 881
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