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反应堆工程

注氘低活化马氏体钢在电子辐照下的缺陷行为

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摘要 低活化铁素体/马氏体（RAFM）钢被视为国际热核聚变反应堆以及聚变反应堆的第1壁候选结构材料之一，很多国家均在研究不同的RAFM钢，中国低活化马氏体（CLAM）钢的研究亦正在进行。核聚变会产生氢、氦、氘及氚，这些气体元素与辐照缺陷结合在一起，对材料的辐照性能会产生较大影响。本文对注氘后不同温度下的辐照后微观结构进行研究。试验利用日本北海道大学的JEOL-1300高压电子显微镜研究注氘CLAM钢从室温到873 K在1 250 keV电子辐照下的微观结构变化。研究结果表明，在电子辐照下，注氘产生的缺陷团会出现消失和长大两种现象，意味着间隙型与空位型位错环在注氘过程中同时产生。并研究了注氘产生的空洞。

关键词 低活化钢 氘 辐照损伤 位错环 空洞

分类号

Behavior of Defects in Deuterium Ions Implanted Reduced Activation Martensitic Steel Under Electron Irradiation

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Abstract Reduced activation ferritic/martensitic (RAFM) steel is considered as the primary candidate of structural materials for the first wall of International Thermal Experimental Reactor (ITER) and fusion power reactors, many countries are developing different kinds of RAFM steels such as F82H and JLF-1 in Japan, 9Cr2WVTa in USA, EUROFER 97 in Europe and so on. Research on China low activation martensitic (CLAM) steel is also undergoing. The neutrons with energy of 14 MeV would produce a large number of crystal defects and in turn cause serious irradiation damages. At the same time, the neutron irradiation will also produce transmutation reactions of (n, p) and (n, α) and results in the formation of helium or hydrogen in materials. These gas atoms may promote the damage behavior during irradiation. This work used ion accelerator to implant ions of deuterium into CLAM steel at room temperature, followed by annealing at high temperature to make the defects develop into large dislocation loops. High voltage microscopy JEOL-1300 was used to investigate the microstructural change in deuterium ions implanted CLAM steel under 1 250 keV electron irradiation at temperatures from room temperature to 873 K. Under the electron irradiation, both of growth and shrinkage of the defect clusters produced by deuterium ions implantation were observed. The results show that both interstitial loops and vacancy loops are formed during the deuterium implantation because the first formed at lower annealing temperature is growing continuously under electron irradiation while the second formed at higher temperature is shrinking due to electron irradiation. The voids produced by the implantation were also studied.

Key words low activation steel _ deuterium _ irradiation damage _ dislocation loop _ void

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