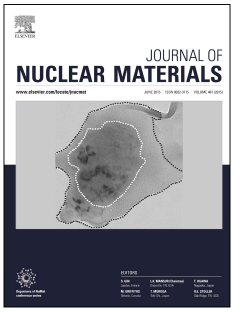

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THE INFLUENCE OF CARBON ON CAVITY EVOLUTION IN ION-IRRADIATED FERRITIC-MARTENSITIC STEELS

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Abstract

Beam-induced carbon uptake has been discovered to occur excessively in high damage ion irradiation experiments. This uptake of carbon has the potential to compromise experiments which aim to emulate the effects of radiation damage. In this study, the effect of carbon on cavity evolution in ion-irradiated ferritic-martensitic steels T91 and HT9 was evaluated. Irradiations were performed with 5.0 MeV Fe^{2+} ions at 460°C to damage levels of 450 dpa. Some samples utilized a 100 nm alumina coating to prevent beam-induced carbon uptake. The T91 samples were pre-implanted with helium concentrations of 0, 1, 10, 100, and 1000 appm and the HT9 samples were irradiated in a dual-beam configuration with 5.0 MeV Fe^{2+} ions and energy-degraded helium up to 188 dpa, with He/dpa ratios of 0, 0.0006, 0.003, 0.015, and 0.2 appm He/dpa. Cavity evolution and carbide formation was characterized using TEM. The effect of carbon uptake on swelling and cavity evolution was evaluated by comparing the results of the samples which experienced excess carbon uptake to irradiated samples which experienced no carbon uptake. It was found that excess carbon suppressed swelling and distorted the role of pre-implanted helium on cavity evolution, regardless of helium injection method. The dissociation of helium bubbles led to a dramatic loss of bubble density at high helium levels by 450 dpa. Significant carbide formation contributed to the dissociation of helium bubbles by providing an alternate sink for emitted helium atoms.

Keywords: ion irradiation, carbon contamination, ferritic-martensitic, swelling, void, cavity, helium

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1. Introduction

Ion irradiation provides a rapid and cost-effective method to evaluate the radiation resistance of candidate nuclear steels. Utilizing ion irradiation, damage levels in the hundreds of dpa can be achieved in several days, which would normally take years in a reactor. Susceptibility to radiation damage in candidate alloys can be quickly assessed. Due to their complex microstructure, ferritic-martensitic alloys have been found to be especially radiation resistant.