STUDIES ON THE EFFECTS OF HELIUM ON THE MICROSTRUCTURAL EVOLUTION OF V-3.8Cr-3.9Ti

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To be published in the proceedings of the symposium on Microstructural Evolution During Irradiation, Symposium B of the Materials Research Society Fall Meeting held in December, 1996.

EXTENDED ABSTRACT

The favorable physical and mechanical properties of V-3.8Cr-3.9Ti (wt.%), when subjected to neutron irradiation, has lead to considerable attention being focused on it for use in fusion reactor structural applications. However, there is limited data on the effects of helium on physical and mechanical properties of this alloy. Understanding these effects are important since helium will be generated by direct α-injection or transmutation reactions in the fusion environment, typically at a rate of $\approx$5 appm He/dpa. Helium has been shown to cause substantial embrittlement, even at room temperature in vanadium and its alloys. Recent simulations of the fusion environment using the Dynamic Helium Charging Experiments (DHCE) have also indicated that the mechanical properties of vanadium alloys are altered by the presence of helium in post-irradiation tests performed at room temperature. While the strengths were lower, room temperature ductilities of the DHCE specimens were higher than those of non-DHCE specimens. These changes have been attributed to the formation of different types of hardening centers in these alloys due to He trapping. Independent thermal desorption experiments suggest that these hardening centers may be associated with helium-vacancy-X (where X= O, N, and C) complexes. These complexes are stable below 290°C and persist at room temperature. However, there has been no direct microstructural evidence correlating the complexes with irradiation effects. An examination of the irradiation induced microstructure in samples preimplanted with He to different levels would enable such a correlation.

In this study the role of helium on the microstructural evolution of V-3.8Cr-3.9Ti has been investigated by in-situ transmission electron microscopy observations of as-prepared and He implanted (<10 appm) samples subjected to 200keV He irradiation at room temperature. Quantitative analysis of the defects showed an increase in the defect density and size with irradiation in both types of samples. The unimplanted sample showed a defect density consistent with previously reported electron irradiation experiments. In comparison, the He preimplanted sample had slightly larger defects and a substantially greater number density of defects.

The large increase in the defect number density caused by He preimplantation as observed in this work is consistent with the formation of He-vacancy-X (X=C,N,O) complexes whose presence alter the interstitial-vacancy populations during irradiation and thus alter the final microstructure. However, consideration of the role of S contaminants, as well as surface C film detected by EDS, may be necessary to completely understand the microstructural differences. In addition, a comparison of the microstructure for higher levels of He implantation would aid in elucidating the behavior of the He-vacancy-X (X=C,N,O) complexes. These activities are in progress.