HELIUM EFFECTS ON IRRADIATION DAMAGE IN V ALLOYS

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OBJECTIVE

The objective of this study is to determine the role of He in the microstructural evolution of V-4Cr-4Ti subjected to a fusion radiation environment by insitu monitored 200keV He ion irradiations using the ion accelerator/intermediate voltage electron microscopy facility at Argonne National laboratories.

SUMMARY

Preliminary investigations were performed on V-4Cr-4Ti samples to observe the effects of He on the irradiation induced microstructural changes by subjecting 3mm electropolished V-4Cr-4Ti TEM disks, with and without prior He implantation, to 200kev He irradiation at room temperature and monitoring, insitu, the microstructural evolution as a function of total dose with an intermediate voltage electron microscope directly connected to an ion implanter. A high density of black dot defects were formed at very low doses in both He pre-implanted and unimplanted samples.

INTRODUCTION

Vanadium alloys have been shown to have substantial advantages for use as structural materials in fusion devices. Among these alloys, V-4Cr-4Ti has been shown to exhibit excellent physical and mechanical properties, both, before and after irradiation. However, the effect of helium on this alloy has still not been fully understood. Recent simulations of the fusion environment using the DHCE experiment[1] have 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. The changes have been attributed to the formation of different types of hardening centers in these alloys. Independent thermal desorption experiments[2-4] suggest that these hardening centers may be associated with helium-vacancy-impurity (for example O, N, and C) complexes. These complexes are stable below 290°C and persist at room temperature. However, there has been no direct evidence correlating the complexes with the irradiation induced microstructure.

This work is a report of our efforts to determine the role of helium on the microstructural evolution of irradiated vanadium alloys by in-situ Transmission Electron Microscopy (TEM) observations of ion irradiated V-4Cr-4Ti

MATERIALS AND PROCEDURES

3mm disks were punched from a 10 mil sheet of V-4Cr-4Ti (Heat ID 832665) which had been subjected to a series of extrusion and rolling processes as described in reference[5]. The disks were then annealed in an inert Ar atmosphere for 1 hour at 1000°C and electropolished to electron transparency. He was implanted into the foils at an energy of 40keV to a total of 500appm at room temperature. The energy of 40keV was chosen as computer simulations using TRIM code[6] showed that it produced the He concentration with damage to the foil. Both the as-prepared and He-implanted samples were ion irradiated with 200keV He ions at room temperature. All the ion irradiation and experimental observations were conducted at the ion accelerator/intermediate voltage electron microscopy facility operated by the Materials Science Division at Argonne National Laboratory.

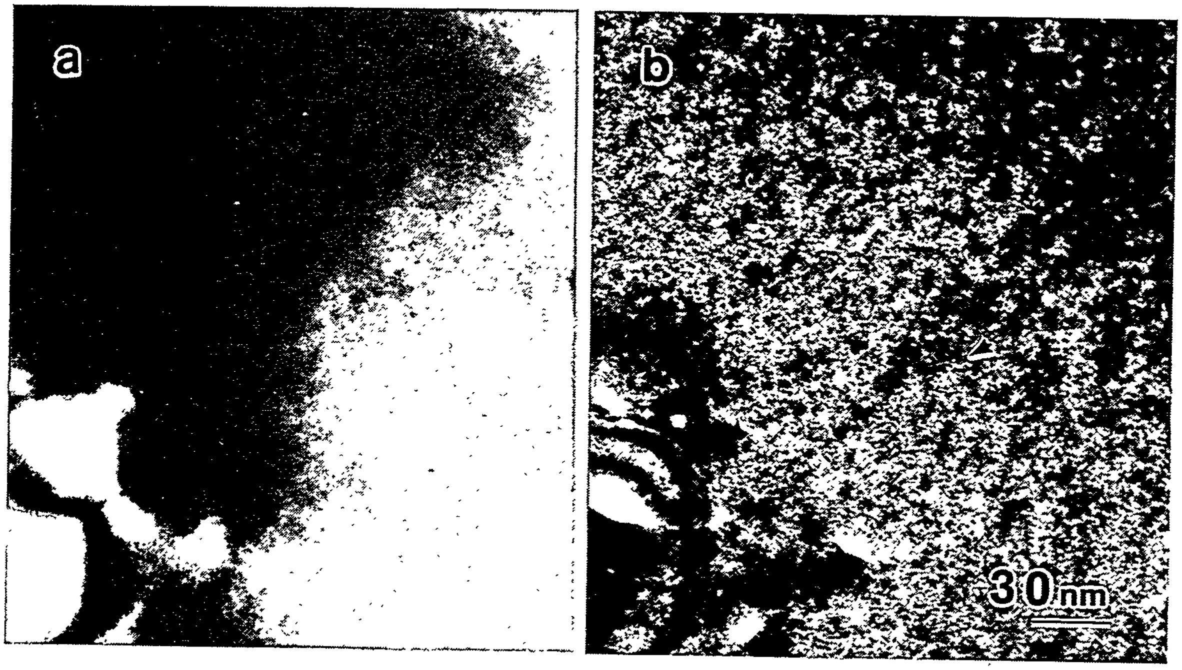

Figure 1: (a) A typical two beam dark field TEM micrograph using the (200) reflection of an unirradiated V-4Cr-4Ti crystal. (b) The same region after 200keV He irradiation imaged using the same two beam conditions. The arrow indicates a black dot defect.

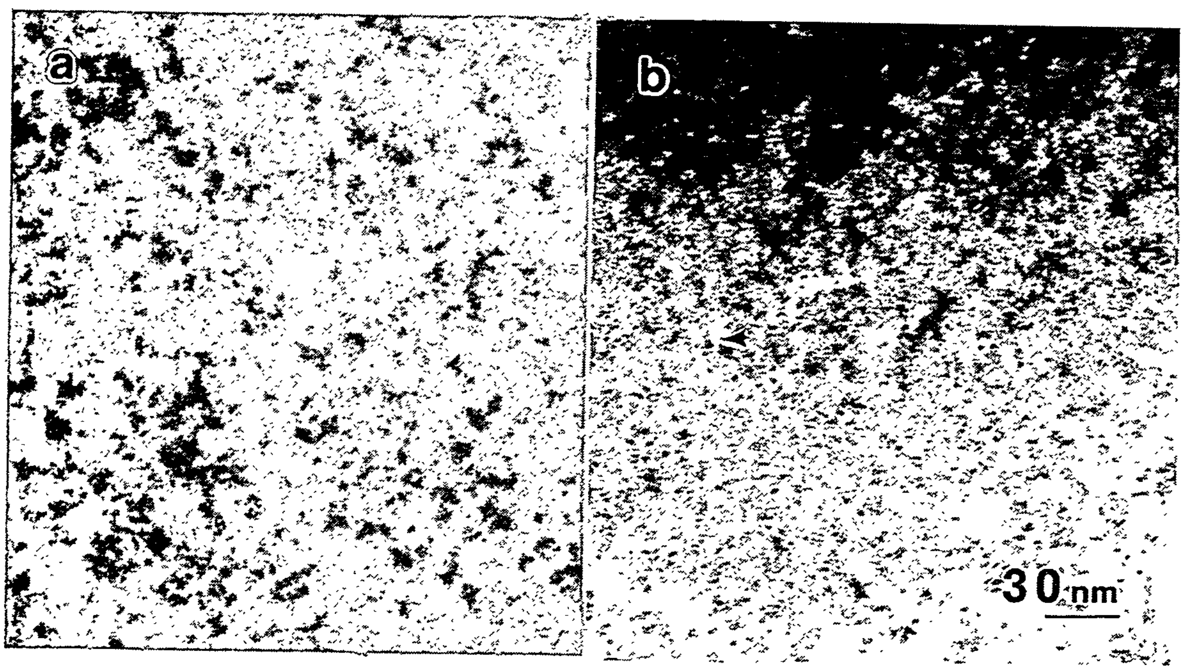

Figure 2: (a) A characteristic two beam dark field TEM micrograph using the (200) reflection of an unirradiated V-4Cr-4Ti crystal pre-implanted with 500 appm He. (b) The same region after 200keV He irradiation imaged using the same two beam conditions. The arrow indicates a black dot defect.

EXPERIMENTAL RESULTS

Fig 1(a) is a typical two beam dark field TEM micrograph using the 200 reflection of an unirradiated V-4Cr-4Ti sample and Fig1(b) that of the same region after irradiation, using the same two beam conditions. The images show the formation of black dot defects with no clear black white lobe contrast. There was no indication of a ring or additional spots in the diffraction pattern which is suggestive of the lack of formation of precipitates. The black dot defects formed at very low doses(6.9×10^{-3} dpa). Similar results were obtained for the He implanted samples. These are shown in fig2. Further analysis is being carried out to determine the number density and size of the defects as functions of the total dose.

FUTURE WORK:

A series of higher dose of He irradiation are planned to be conducted on both the unimplanted and implanted V-4Cr-4Ti samples at room temperature and temperatures greater than 290°C. The study will allow for the determination of the effect of He and the role of He-vacancy-interstitial complexes by the microstructural change in size and density of defects generated in V-4Cr-4Ti.

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