TEMPERATURE DEPENDENCE OF THE RADIATION DAMAGE MICROSTRUCTURE IN V-4Cr-4Ti NEUTRON IRRADIATED TO LOW DOSE* — P. M. Rice and S. J. Zinkle (Oak Ridge National Laboratory)

Extended Abstract

Transmission electron microscopy (TEM) was performed on the US program heat of V-4Cr-4Ti (heat #83665) irradiated to damage levels of 0.1-0.5 displacements per atom (dpa) at 110-505°C in the High Flux Beam Reactor at Brookhaven. A high density (~$1 \times 10^{23}/m^3$) of small (~3.0 nm diameter) faulted dislocation loops were observed at irradiation temperatures below 275°C. These dislocation loops became unfaulted at temperatures above ~275°C, and a high density of small Ti-rich defect clusters lying on {001} planes appeared along with the unfaulted loops at temperatures above 300°C. The density of the {001} defect clusters was much higher than that of the dislocation loops at all temperatures above ~300°C. The density of both types of defects decreased with increasing temperature above 300°C, with the most rapid decrease occurring for temperatures above 400°C. Based on the TEM and tensile measurements, the dislocation barrier strengths of the faulted dislocation loops and {001} defect clusters are ~0.4-0.5 and 0.25, respectively. This indicates that both types of defects can be easily sheared by dislocations during deformation. Cleared dislocation channels were observed following tensile deformation in a specimen irradiated at 268°C.

The microstructural investigation of V-4Cr-4Ti specimens irradiated to relatively low fission neutron doses of 0.1 to 0.5 dpa demonstrated that several complex radiation processes occur. The microstructure was independent of temperature between 110 and ~275°C, where it was composed of a high density of small faulted (b=a/2<110>) dislocation loops. The high density and low barrier strength of these dislocation loops produce significant radiation hardening with a concomitant sharp decrease in uniform elongation and an increase in the ductile to brittle transition temperature.

Loop unfaulting occurred over a rather narrow temperature range centered near 300°C, and a high density of defect clusters on {001} habit planes was observed from 315°C up to the maximum irradiation temperature in this study of 505°C. The {001} defect clusters were enriched in Ti at elevated temperatures, and their displacement vector was determined to be a/3<001> at 505°C. These {001} defect clusters may be the precursors of the Ti-rich precipitates reported in higher dose studies at temperatures $\geq$ 400°C.

It would be useful to investigate the microstructure of irradiated V-4Cr-4Ti at relatively low doses of 0.1 to 10 dpa to provide further insight into the microstructural evolution which occurs at temperatures above 400°C.

*Extended abstract of paper submitted to Journal of Nuclear Materials as part of the proceedings of the 8th International Conference on Fusion Reactor Materials, Sendai, Japan, October 27-31, 1997.