§91. Microstructural Evolution in Vanadium during Ion Irradiation at Constant and Varying Temperature

Ochiai, K., Watanabe, H., Yoshida, N. (Kyushu University)
Matsui , H. (Tohoku University)
Muroga, T.

Vanadium base alloys are considered to be a candidate low activation structural material for fusion reactors. Since temperature of fusion components are expected to change widely depending on the operation history, irradiation response of the components may be different from that predicate by isothermal experiments. In the present study, heavy ion irradiations of pure vanadium and vanadium base alloys were carried out with changing temperature in a stepwise manner from low to high temperature to investigate the basic mechanisms of the temperature transient effects on microstructural evolution.

Pure vanadium and two model alloys (V-5Cr, V-5Ti) were used in this study. Disk specimens were wrapped with pure zirconium as a getter of oxygen and annealed for two hours at 1373K. Irradiation was performed using 3 MeV Cu ions in the temperature range of 473-873K. In addition to constant temperature, irradiation temperature was changed cyclically between two temperatures. The combinations of the temperatures of the irradiation were 473K(0.25dpa)/873K(0.5dpa) and 673K(0.25dpa)/773K(0.5dpa).

In pure vanadium, density of defect cluster decreased with increasing irradiation temperature. Above 773K(0.75dpa), needle-like precipitates, which were oriented along <100> directions, were observed. Void formation was detected in the temperature range where the needle-like precipitates were formed. The precipitates formed at 873K(0.5dpa) were dissolved by prolonged irradiation at 873K or additional low dose irradiation at 473K(0.02dpa).

In the case of stepwise change of irradiation temperature, defect cluster density was strongly affected by the pre-irradiation temperatures as shown in Fig.1. In the case of temperature-variant 473K(0.25dpa)/873K(0.5dpa) irradiation, the defect density of 2 x 10^{22} m^{-3} at 473K was decreased to 1 x 10^{20} m^{-3} by the irradiation at 873K. In the case of 673K of the pre-irradiation temperature, however, the amount of recovery by annealing or irradiation at 873 K is smaller. The phenomena were explained qualitatively by the appearance of vacancy-rich conditions after the change from low to high temperature.

The understanding obtained by the present study will be applied to the design and analysis of the Varying Temperature Irradiation Experiment to be carried out in HFIR under Japan-USA Fusion Cooperation Program (JUPITER project).

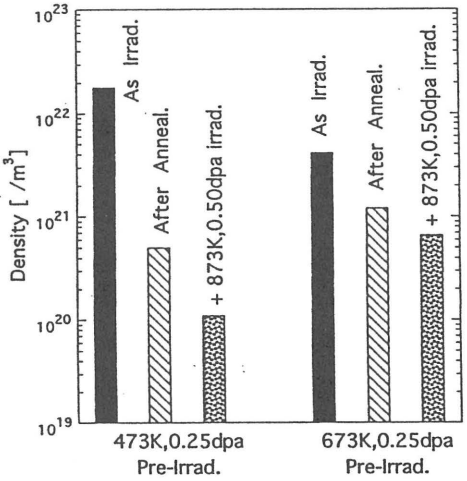

Fig. 1 Density of defects observed in vanadium by heavy ion irradiations. Results after pre-irradiation, after annealing and after succeeding high temperature irradiation are compared in two cases of the pre-irradiation temperature.