§4. Effects of Impurities on the Behavior of Helium-Defect Complexes in Vanadium

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Introduction

Vanadium alloys are considered to be one of the leading candidates for the fusion reactor blanket material. Although vanadium has many attractive features, its use at high temperature may be limited by helium embrittlement. Effects of the helium on the macroscopic mechanical properties have been studied rather extensively, while the evolution processes of helium-defect complex, especially during earlier stage is not clearly understood. This is mainly because of the complexity of Helium behavior in vanadium caused by large amount of interstitial impurities (C, N, O) in the matrix. The objective of present paper is to investigate effects of impurities on early stages of helium clustering, using THDS (Thermal Helium Desorption Spectrometry), one of the most effective techniques to study He-V-X(X=C,N,O) type complexes.

Experimental procedures

Specimens used were pure vanadium. Oxygen contents in samples were systematically controlled by regulating the atmosphere during annealing and by using Zr-treatment technique (Table. 1). THDS were performed in the following manner to examine the nature and behavior of helium-defect complexes. First, helium implantation at the accelerating voltage of 1keV(defect induced) were conducted up to 3.2×10^{17} ions/m^2, then the specimen was heated to 1700K at a constant rate of 40K/s while monitoring the release rate of helium gas with quadropole mass spectrometer.

Sample	Oxygen (at. ppm)	Nitrogen (at. ppm)
0-5865	5865	89
0-838	838	40
0-112	112	47

Table.1 Impurity concentration in vanadium

Results and discussions

Helium desorption rates as the function of heating temperature were plotted in Fig. 1. Several desorption peaks have been observed and these peaks may be concerned with vacancy type defects which are one of the effective trap sites of helium in metals. Prominent peaks appeared at 530-580,680-730,and 860-960K; referred to as A-, B- and, C-peak. Earlier studies assigned these peaks as He_nOV, He_nOV_2 and He_nOV_m, respectively. Broad peaks appeared above 1100K correspond to the helium desorption from bubbles. D peak was detected when the concentration of oxygen was extremely low (112appm) where population of A peak is low. D peak was determined as HeOV peak. Population of A peak decreases with increasing oxygen concentration from 838 to 5865 appm, because the IV recombination was enhanced due to the lower mobility of SIA which is trapped by oxygen. Peak A was split into double peaks (530 and 580K). Fig. 1 Thermal desorption spectra of vanadium

Conclusions

1 HeV clusters were detected when the concentration of oxygen was extremely low (112appm)

2 Population of A peak decreases with increasing oxygen concentration, because the IV recombination was enhanced due to the lower mobility of SIA which is trapped by oxygen.

3 A and C peaks shifted to higher temperatures due to higher concentration of oxygen, in addition, peak A was split into double peaks (530 and 580K)