4Dp05

低放射化バナジウム合金の機械特性に及ぼす不純物窒素とチタン濃度の影響
Effect of nitrogen and titanium concentrations on mechanical properties of low-activation vanadium alloys

齋藤千貴[1]、長坂琢也[1,2]、小林真[1,2]、申晶潔[2]、山崎樂[1]、
チザールバレンチン[2,3]、室賀健夫[1,2]
SAITO Kazuki[1], NAGASAKA Takuya[1,2], KOBAYASHI Makoto[1,2], SHEN Jingjie[2], YAMAZAKI Gaku[1], TSISAR Valentyn[2,3], MUROGA Takeo[1,2]

[1]総合研究大学院大学、[2]核融合科学研究所、[3]カールスルーエ工科大学
[1]SOKENDAI, [2]NIFS, [3]KIT

1. Introduction

Low-activation vanadium alloys have been candidate structural materials for fusion blanket systems with liquid breeder lithium. One of the alloying elements, titanium, forms precipitates with the interstitial impurity nitrogen which is the contaminant transferred from liquid lithium. As a result, titanium scavenges nitrogen from the alloy matrix. The scavenging suppresses solid solution hardening by the contamination and thereby maintains the ductility of the alloys in lithium. On the other hand, titanium creates a long-lived radioactive nuclide under the fusion neutron irradiation, therefore it is necessary to minimize its concentration in the vanadium alloys. In order to understand the scavenging effect and to optimize the titanium concentration, the present study simulates the nitrogen contamination by nitrogen gas exposure experiment, and seeks the correlation between the nitrogen diffusion and/or precipitation behaviors and the mechanical properties.

2. Experimental

Table 1 lists the chemical compositions of the vanadium alloys used. After electro-polishing on the surface, nitrogen gas exposure (nitrogenizing) was conducted at 650 ºC for 25 hours. Post-nitrogenizing annealing was performed at 800 ºC for 1 hour. The mechanical properties of the nitrogenized alloys were evaluated by Vickers hardness tests and tensile tests. In addition, chemical analysis by X-ray photoelectron spectroscopy (XPS) and cross section observation by scanning electron microscope (SEM) were performed.

3. Results and discussion

Fig. 1 shows the difference in the hardening of the surface before and after the nitrogen exposure as a function of the titanium concentration in the alloys. As the concentration of titanium increased, the hardening increased. Then, it indicated a saturation at 2 mass%. The alloys with high titanium content exhibited great hardening of 700–800 VHN, although the scavenging effect of titanium on nitrogen was expected in this high titanium content region. One of the possible mechanisms is the precipitation hardening induced by the high number density formation of titanium precipitates. It was considered that precipitation is saturated around the region of 2 mass% titanium. Hardening and precipitate distribution on the cross section, tensile properties after the nitrogenizing, and effects of the post-nitrogenizing annealing will be reported and discussed in the presentation.

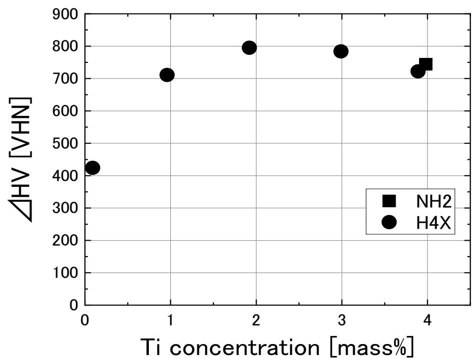

Fig. 1. Increase of Vickers hardness on the surfaces of vanadium alloys after gas nitrogenization as a function of the Ti concentration in the material.

Table 1. Compositions of vanadium alloys [mass%].

Ref. ID	Composition	V	Cr	Ti	C	N	O	Mo	Al	Si
NH2	V-4Cr-4Ti	Bal.	4.02	3.98	0.0069	0.0122	0.0148	0.0024	0.0059	0.027
H44	V-4Cr-4Ti	Bal.	4.11	3.89	0.008	0.003	0.018	0.00023	0.018	0.094
H43	V-4Cr-3Ti	Bal.	3.92	2.99	0.009	0.003	0.016	NA	0.007	NA
H42	V-4Cr-2Ti	Bal.	3.89	1.92	0.008	0.003	0.015	NA	0.006	NA
H41	V-4Cr-1Ti	Bal.	4.02	0.96	0.008	0.004	0.016	NA	0.009	NA
H4T	V-4Cr-0.1Ti	Bal.	3.90	0.09	0.007	0.003	0.017	NA	0.011	NA