§3. Effect of Impurity Levels on Precipitation Behavior in the Low-activation V-4Cr-4Ti Alloys

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The mechanical properties are varied by the formation and resolution of precipitates including impurities in a low-activation V-4Cr-4Ti alloy. Especially, it is well known that the change of interstitial impurity content in base metal results in the change of DBTT, caused by the formation and the resolution of precipitates.

Recently high-purity V-4Cr-4Ti ingots, NIFS-HEAT-1and 2, were fabricated by NIFS (National Institute for Fusion Science). To understand the effect of the formation and resolution of precipitate on the various properties in NIFS-HEAT, it is necessary to clarify the effect of impurities on precipitation.

The purpose of this study is to clarify the effect of impurities on precipitation behavior and the hardness change by heat history, using V-4Cr-4Ti alloys with different oxygen levels.

Table 1 shows the levels of interstitial impurities in the V-4Cr-4Ti alloys used in this study. Especially, they were very different in the oxygen contents. NIFS- HEAT-1 and US 832665 are large heats of NIFS and US, respectively. Other model alloys were fabricated by arc melting. All the specimens were cold-rolled more than 50% reduction, followed by annealing at 1373K for an hour in a vacuum ($<10^{-5}$ Torr.) for the solution treatment of interstitial impurity and the removal of dislocation. Then they were annealed again from 873 K to 1373 K for an hour to investigate the effect of impurity levels on precipitation behavior. Hardness measurement and microstructure observation were carried out. Figure 1 shows the relation between hardness change and heat treatment temperature. The peak of hardness was found at 973 K each specimen. Intensity of the peak increased with increasing oxygen level in model alloys. Compared with model alloys, however, two large heats were different from model alloys in the intensity behavior of the peak. It is thought that the reason is due to the existence of oxygen, which did not dissolve during the solution treatment at 1373 K. Figure 2 shows the TEM images of specimens heat-treated at 973K. From the result of the TEM observation, it appears that the amount of the tiny precipitates increases with increasing the oxygen content. The peak was good relation to the precipitate formation, and its intensity was closely related to the number density of precipitate.

From this study, hardness increased with increasing the oxygen content in V-4Cr-4Ti model alloys, regardless of impurity states, for example, formation and resolution of precipitates. Two large heats, however, were not the same tendency to the model alloys. It is thought that it is due to the difference in heat history or thermomechanical treatment before this study.

Table 1. Chemical compositions of the materials used.

	wt%		wppm		
	Cr	Ti	C	N	O
NIFS-HEAT-1	4.12	4.13	56	103	181
US832665	3.8	3.9	80	85	310
HP3	3.94	3.81	75	88	44
VA-O-1	3.98	4.11	56	115	244
VA-O-2	3.95	3.94	89	125	513

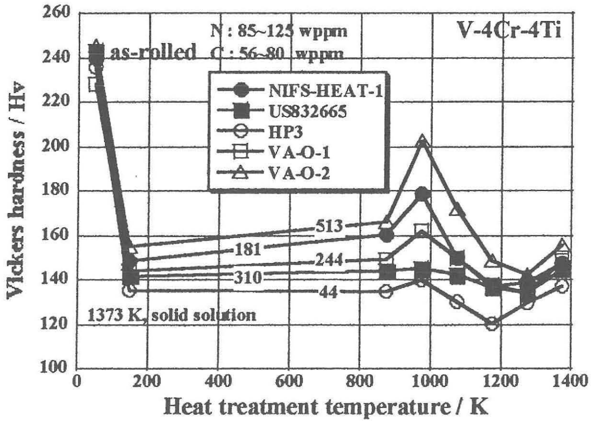

Figure 1. Change of hardness with annealing temperature in V-4Cr-4Ti alloys with the different impurity level

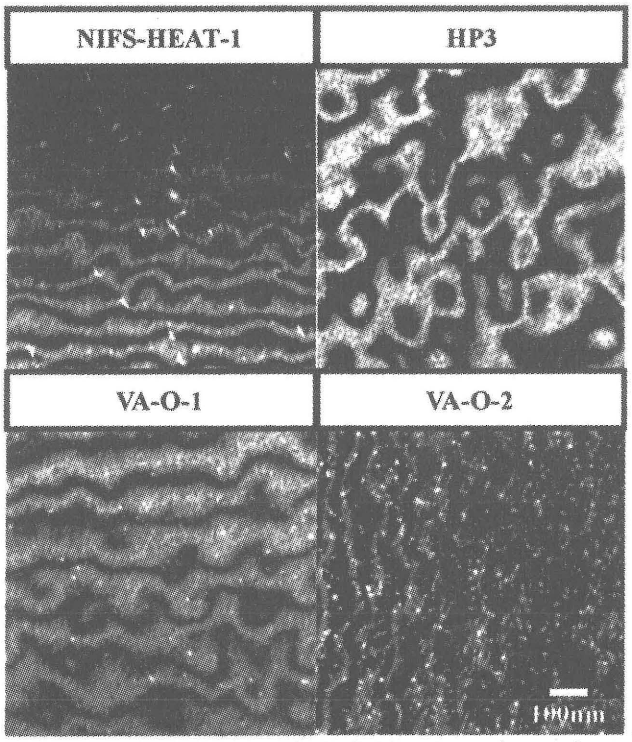

Figure 2. TEM images (dark field) of specimens heat-treated at 973K.