§17. A Study of Strengthening for V-4Cr-4Ti Alloy by Mechanical Alloying

Zheng, P.F. (Grad. Univ. Advanced Studies),
Nagasaka, T., Muroga, T.,
Chen, J.M. (SWIP)

V-4Cr-4Ti alloy has been identified as the first candidate structural material for Li blanket component in a fusion reactor, because of its low activation property, high strength at elevated temperatures, and good compatibility with liquid Li. [1] However, in order to improve thermal efficiency of the blanket by higher temperature operation, it is necessary to enhance the creep strength of this material. A thermomechanical treatment combines work hardening followed by precipitation hardening was shown to be efficient to enhance the creep strength of V-4Cr-4Ti alloy in stress region above 180MPa, but not efficient below 180MPa. [2]

Recently, a nano-particle dispersion strengthening technique has been applied widely on fusion structural materials including vanadium alloys. [3] The pinning of dislocations by the dispersed nano-particles largely increases the strength of the materials at both RT and high temperatures. However, the research activities on dispersion strengthening of V-4Cr-4Ti are still not enough.

In this study, a new series of V-4Cr-4Ti alloys have been fabricated with nano-particle dispersion coupled with grain size refining by mechanical alloying (MA). Y is used as the scavenger for N and O impurities. With TiC, SiC, Ti_3SiC_2 as dispersion particles, and WC/Co as the milling ball materials, MA process of V-4Cr-4Ti alloys with Y addition has been studied with different milling time. The dissolution behaviors of alloying elements in V matrix and dissolution effects of dispersion carbides on alloy hardness are discussed.

Results show that the collision-induced dissolution rate of Y into V matrix is higher than that of Cr, and, the dissolution rate of Cr is higher than that of Ti, as shown in Fig. 1.

The strengthening of the V-4Cr-4Ti alloys increases with increasing MA time. After annealing at 1200°C for 1hr, the strengthening increases with increasing MA time, especially above 10hrs (as shown in Fig. 2). The poor dissolution of Ti_3SiC_2 (marked as TiSiC) particles leads to less hardening for the V-4Cr-4Ti alloys, because it may retard the solid solution hardening and further nano-particle dispersion strengthening. It is considered that the dissolution of Ti could be an important factor to stabilize the microstructures of obstacles in the mechanical alloyed V-4Cr-4Ti. Y-rich and especially Ti-rich nano-particles are considered to be important particles to strengthen the V-4Cr-4Ti alloys.

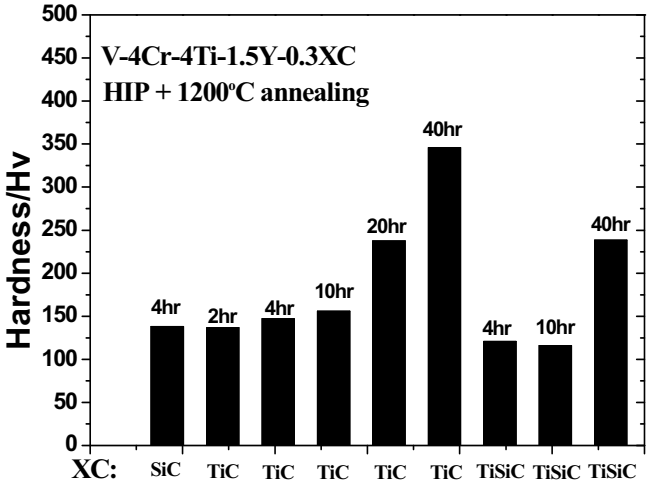

Fig. 2. Hardness of Y and carbides added V-4Cr-4Ti alloys after annealing at 1200°C for 1hr.

1) T. Muroga. et al.: Fus. Eng. Des. **61-62** (2002) 13-25.
2) P. F. Zheng. et al.: Fus. Eng. Des. **86** (2011), 2561-2564
3) H. Kurishita. et al.: **367–370** (2007) 848-852.

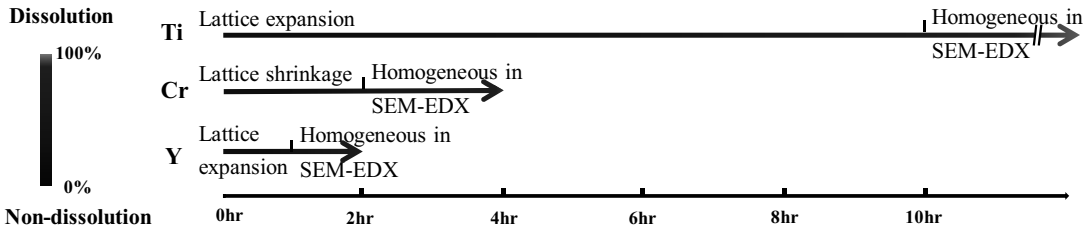

Fig. 1. Possible dissolution history of Ti, Cr and Y in V matrix.