§19. Effect of Li Exposure on the Mechanical Properties of Pure V and V-4Cr-4Ti Alloy

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V-4Cr-4Ti alloy is a leading candidate structural material for self-cooled liquid Li blanket of a fusion reactor.[1] The interactions of liquid Li and the V-4Cr-4Ti alloy are of concern, because the mass transfer in Li/V system can influence the mechanical properties of V-4Cr-4Ti, thus change its service performance. As Li exposures for V-4Cr-4Ti alloy at 700°C which is the designed operation temperature, and at 800°C have been researched in some previous studies,[2] this study deals with the mechanical properties of V-4Cr-4Ti after Li exposure at 650°C.

The V-4Cr-4Ti alloy is thermomechanically treated using standard heat treatment (STD: 1000°C for 2hrs), precipitation hardening (SAA: solid solution annealed at 1100°C for 1hr +aging at 600°C for 20hrs) and a work hardening plus precipitation hardening (SACWA: solid solution annealed at 1100°C for 1hr + 20% cold work + aging at 600°C for 20hrs). Pure vanadium is used for investigation on the effects of the alloying elements, e.g. Ti, on the mass transfer. Then the specimens are exposed to liquid Li and vacuum at 650°C for 248hrs. Mechanical properties are measured at RT and high temperatures. Microstructures are observed to study the mechanism of the mechanical property change.

The present Li exposure has softened pure vanadium because Li absorbs O from vanadium matrix.[3] However, the Li exposure strengthens the V-4Cr-4Ti alloy. A significant strengthening appears near the surface areas, which agrees with the diffusion range of N in vanadium matrix (shown as Fig. 1) based on the equation:

$$d \approx \sqrt{D \times t} \qquad (1)$$

where d is the diffusion range, D is diffusion coefficient and t is diffusion time. The mechanism of the strengthening is considered to be precipitation hardening induced by Ti precipitates, which contain N and C transferred from the liquid Li. And this strengthening can be more effective than the softening due to loss of O and decrease in dislocation and precipitate number density during the aging.

1) Muroga, T. et al.: J. Nucl. Mater. **307-311** (2002) 457.
2) Li, M. et al.: J. Nucl. Mater. **367-370** (2007) 788.
3) Nagasaka, T. et al.: Fus. Eng. Des. **81** (2006) 312.

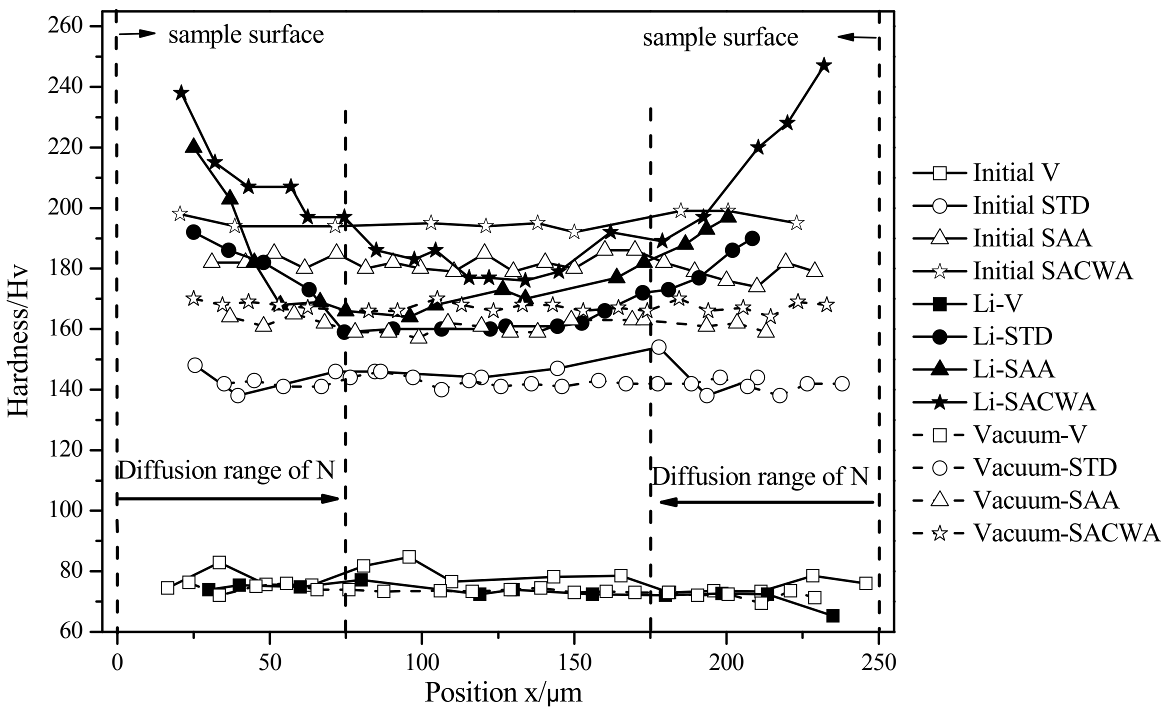

Fig. 1. Distribution of cross section hardness for pure V and V-4Cr-4Ti in different states。