# Effects of Annealing Temperature on Microstructure and Mechanical Properties of High Purity Vanadium alloys

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Abstract (approx. 55words)
In this study, aiming at revealing the precipitation and recrystallization behavior of the high purity V-Cr-Ti system with various levels of Cr and Ti, the effects of annealing temperature on microstructure and mechanical property of cold-rolled vanadium alloys were investigated.

**Keywords:** High purity vanadium alloy, annealing, precipitation, hardness, tensile properties

## 1. Introduction

Low-activation vanadium (V) alloy is regarded as a candidate structural material for fusion reactor. To shorten the recycling periods of vanadium alloy after fusion reactor shutdown, high-activation impurities like cobalt, niobium, molybdenum etc. were reduced by refinement melting. Further improving the low-activation characteristic of V-Cr-Ti system is to reduce Ti concentration, which produces long-lived isotopes under neutron irradiation. On the other hand, Ti reduction degrades the strength of the alloy. Increasing Cr concentration is expected to compensate for the strength loss. High purity vanadium alloys containing about 300 mass ppm interstitial impurities (e.g., carbon, nitrogen, oxygen) with various levels of Ti and Cr concentration were developed. Aiming at revealing the precipitation and recrystallization behavior of the high purity V-Cr-Ti alloys, the effects of annealing temperature on microstructure and mechanical property of cold-rolled vanadium alloys were investigated.

## 2. Experimental

High purity V alloys with nominal chemical composition of V-4Cr-xTi (x=0, 0.1, 1, 2, 3, 4, in mass%) and V-yCr-1Ti (y=4, 6, 8, 10, 12, in mass%) were fabricated by arc-melting process. Button ingots were sealed, and hot forged in the temperature range of 1273 – 1473 K. Then, they were cold rolled to sheets with final thickness of about 0.25 mm. Discs and SSJ tensile specimens were punched out from the sheets. Thermal annealing was conducted at 873 - 1273 K for 1 h in a vacuum. Microstructure was characterized by scanning electron microscopy and transmission electron microscopy. Vickers hardness and tensile tests were performed at room temperature.

## 3. Conclusion

Hardness decreased with increasing annealing temperature to the minimum at 1173 K mainly due to recovery of dislocations and recrystallization, and then increased a little at 1273 K. Precipitation of Ti-CON was observed at 973 K for 1%Ti and above. Based on the microstructural analyses and Orowan's mechanisms, precipitation hardening increased up to 2%Ti, leveled off at 3%Ti, and decreased for 4%Ti after both 1173 K and 1273 K annealing, indicating 2~3%Ti addition results in more precipitation hardening than 1% and 4%. The effects of Cr concentration on the precipitation and tensile properties will be also reported and discussed.