Fabrication and evaluation of Ti-V-Cr hydrogen storage alloy

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Ti-V-Cr alloys are known to absorb (desorb) nearly 2.6wt% of hydrogen. The hydrogen storage properties of (30-36%)Ti-(30%)V-(34-40%)Cr compositions were studied in this paper. The plateau pressure of Ti-30V-(40-x)Cr (x=0, 3, 6) alloys increased with increasing Cr content. The properties of the Ti-35V-40Cr alloy were already studied with heat treatment was annealing 1173-1623K f by 1hour, and quenched into iced water. The alloy of 33Ti-30V-37Cr exhibits an effective hydrogen capacity of 2.1wt% at 373K.

Keywords: hydrogen storage alloy, titanium-vanadium-chromium, body centered cubic phase, face centered cubic phase, low hydrogen pressure region.

I. INTRODUCTION

Hydrogen is considered by many analysts to be the most promising energy carrier in the long term and its pollution-free conversion into energy by fuel cells is a very attractive feature. Hydrogen absorption alloys, such as $LaNi_5$, Mg_2Ni, $MmNi_5$ etc., have been widely used as secondary electric batteries.

Vanadium based solution with a BCC structure known to good absorb of hydrogen. Iba *et al.* reported that a Ti-40V-35Cr alloy could desorb about 2.4wt% hydrogen [1]. And Tominaga *et al.* also reported Ti-35V-40Cr alloy could 2.6wt% effective hydrogen capacity [2].

Therefore, the purpose of this study is to explain the hydrogen absorption-desorption of Ti-30V-Cr alloys under the heat-treatment conditions.

II. EXPERIMENTAL DETAIL

In this study, the Ti-V-Cr alloy was chosen as starting composition. The purities of raw materials, including titanium, vanadium, chromium in this study 99.6%, 99.9%, 99.9% respectively.

Alloys	Compositions	Ti/Cr
A	30Ti-V-40Cr	0.75
B	33Ti-V-37Cr	0.89
C	36Ti-V-34Cr	1.05

The alloys will be prepared from raw materials by arc- melting on a water-cooled copper hearth under pure argon atmosphere. Melting time is about 40 seconds 3 times each compounds. The samples heated to 1573K, annealed for 1 hour, and quenched into iced-water.

Crystal structure was studied by X-ray diffractometer (XRD) using Cu-Kα radiation by Rigaku SmartLab. The Pressure-composition-temperature (PCT) curves from 0.01MPa to 10MPa were measured for three cycles each at 373K, 383K, 393K and 403K using a Sieverts-type apparatus. the samples were examined by thermal desorption mass spectroscopy (TDMS) (Rigaku MIGT11-002) combined with thermogravimetry (TG) upon heating up to 500°C with a heating rate of 5°C/min.

III. RESULTS AND DISCUSSIONS

Figure 1 shows PCT curves (absorption and desorption) at 373K from 0.01MPa to 9.8MPa for A, B, C alloys.

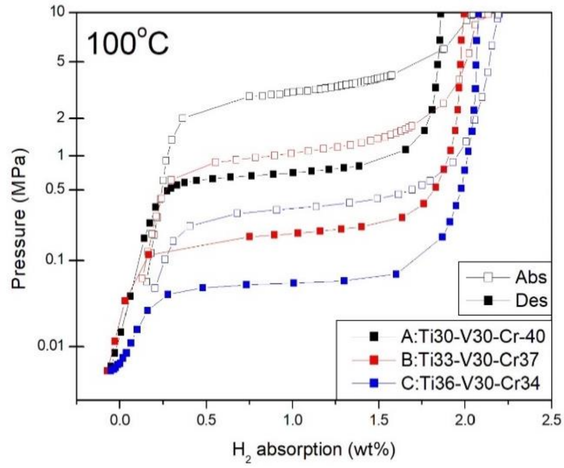

Fig 1. PCT curves (absorption and desorption) at 373K for A, B, C alloys.

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The high state pressure of this compounds were observed to decrease with Cr amount is decreasing. Therefore, we observe all compounds hydrogen capacities of nearly 2.1 wt%.

We can also measure Hydrogen storage properties (from above) and enthalpy and entropy value of compound. Figure 2 shows Van't Hoff plot at 373K, 383K, 393K and 403K for to find enthalpy and entropy. The B alloy (33Ti-V-37Cr) have entropy is equal to 138 J/K, enthalpy is equal to 49 kJ/mol.

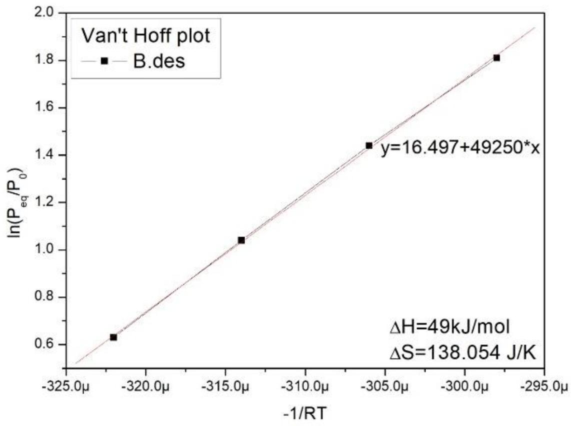

Fig 2. Van't Hoff plot at 373K, 383K, 393K and 403K.

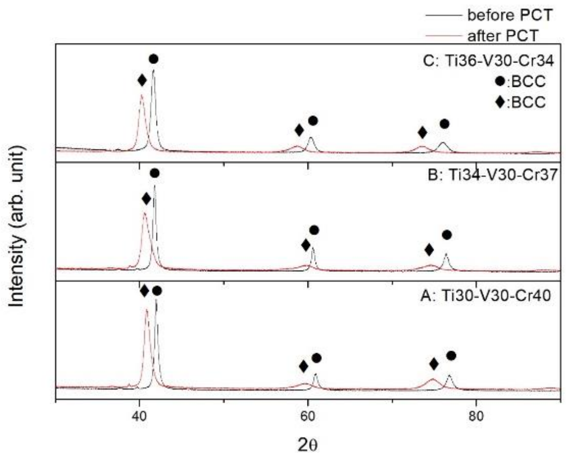

Fig 3. XRD pattern about compare between before PCT and after PCT for C alloy.

Figure 3 shows XRD pattern for C alloy. It was found by XRD that all studied alloy had a BCC single phase. Ti amount is increasing that relating to lattice parameter. And we can see that after the PCT measurement, XRD peaks are shifting left side. That means cells are expanding as effects of hydrogen.

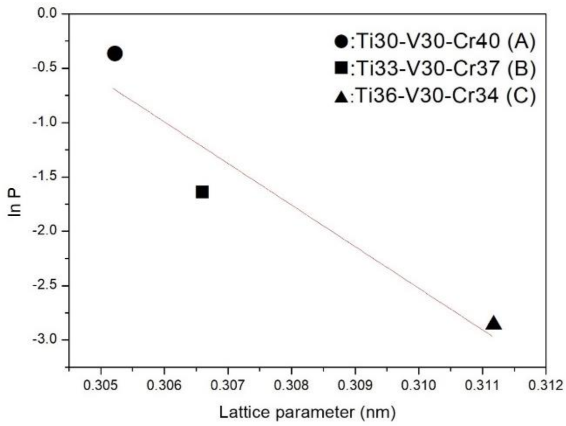

Fig 4. Lattice parameter for A, B, C alloys.

Figure 4 shows lattice parameter relation pressure linear. We consider relation between lattice parameter and equilibrium pressure. It do not seems to be linear. We expected equilibrium pressure is linear proportion with lattice parameter. We change composition amount. So this figure is effect of equilibrium pressure related by composition amount.

We wants to analyze more closely about absorption and desorption effect. Figure 3 shows first absorption and desorption with three main point by using TGMS and XRD apparatus.

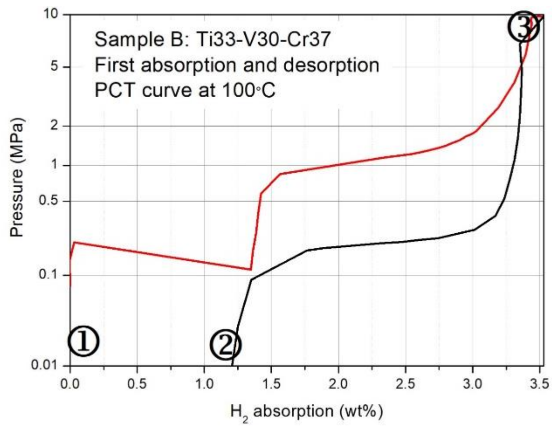

Fig 5. Figure of first absorption and desorption with three main points.

Figure 6 shows XRD pattern for three main points. That three points gradually increase hydrogenation. The sample before hydrogenation has BCC single phase. The samples of two different BCC phases. These results show that the sample situated in the second plateau regions transforming BCC phase to FCC single phase.

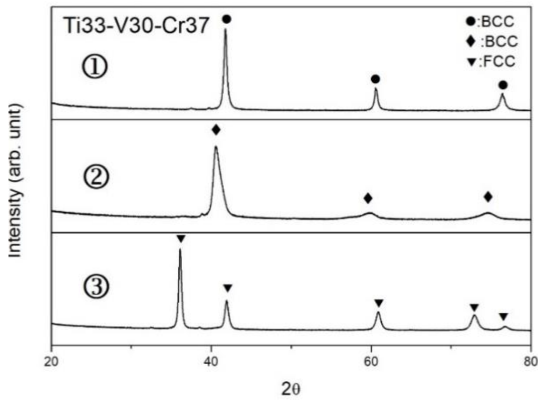

Fig 6. XRD pattern for three main points.

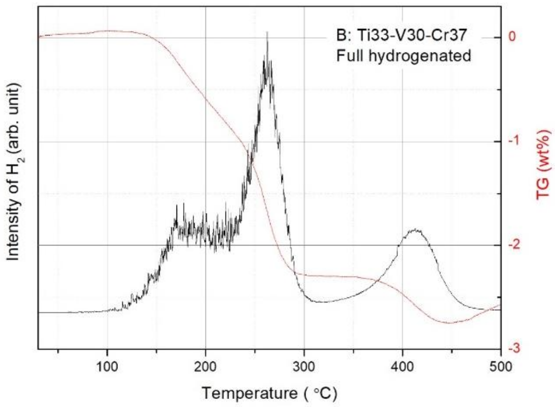

Fig 7. TG-MS of hydrogen for 33Ti-30V-37Cr of full hydrogenated state.

Figure 7 shows TG-MS of hydrogen (H2) gas for B type sample (Ti33-V30-Cr37) of full hydrogenated state. It equals 2.74% mass of hydrogen. It is different from previous value of PCT graph. While we were sealing full hydrogenated sample under acetone atmosphere, lose a small hydrogen to atmosphere.

IV. CONCLUSION

Hydrogen storage properties of Ti-V-Cr alloys were studied. In this alloys contains constantly 30wt% V, change value Ti/Cr=x (x= 0.75, 0.89, 1.05), were investigate this conclusions.

1. The equilibrium pressure of (30+x)Ti – 30V – (40-x) Cr (x=0, 3, 6) compounds increased, resulting from increasing Cr contents.
2. We tried to measure enthalpy of one of samples. It is $\Delta H = 48kJ$. And this alloys ability of hydrogen capacities of about 2.1wt% (H_2).
3. Ti-V-Cr alloys with BCC structure processes for hydrogenation. That process was lattice parameter becomes getting larger while starting hydrogenation. Finally it transformed to FCC structure at the full hydrogenated state.

From TG-MS apparatus, we observe two different peaks. It means Ti-V-Cr alloys have two sites for hydrogen storage.

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