Effects of Transition Metal-based Catalysts on the Hydrogen Permeability of V Membranes

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Ultra pure hydrogen (UPH) is widely used for semiconductor processing, oil refining, chemical synthesis and proton exchange membrane fuel cell (PEMFC). UPH is mainly produced by removing CO, CO_2, H_2O and other impurities from the syngas generated by coal gasification and natural gas reforming process. Generally, pressure swing adsorption (PSA) process using different adsorption properties for an adsorbent material of gas species depending on pressure is applied to the final stage of the H_2 separation. However, the purity of H2 gas produced by the PSA process is about 99.999 wt.% and CO of several ppm remains in the purified gas. It is well known that the CO concentration of fuel gas is very important for the efficiency and durability of the PEMFC because the surface of Pt catalyst in the PEMFC is poisoned by CO very sensitively. In order to prevent CO poisoning of the catalyst, it is desirable for the PEMFC to use the UPH containing less than 1 ppm CO.

H_2 separation membrane is one of the most attractive candidates for the mass production of the UPH. The H_2 permeation properties of various materials such as polymer, ceramic, carbon and metal have been studied. Among them, dense metal membrane has the advantages of both high H_2 selectivity and high H_2 permeability. There have been extensive studies on Pd and Pd alloys such as Pd-Ag, Pd-Au and Pd-Cu as a H_2 separation membrane material due to their high H_2 permeability [1]. However, the Pd-based membrane is very expensive due to the noble metal Pd of about $700/oz.

In order to alternate the Pd-based membrane, V-based H_2 separation membrane has been developed. It has been reported that the H_2 permeability of V with BCC structure is higher than that of Pd with FCC [2]. Interestingly, most of the V alloy membranes have a Pd layer, which is coated by sputtering method with about 150 nm thickness, on the both surfaces to compensate for the very low H_2 dissociation/recombination catalytic properties of the V alloys. Therefore, to commercialize the V alloy membrane for H_2 separation successfully, it is essential to develop a non-Pd-based catalytic layer by a simple process. However, there are few reports on the effects of the non-Pd-based catalytic layer on the H_2 permeability of the V alloy membranes.

In the present work, we electrodeposited the Ni and Co-based catalytic layers on the V substrates under various deposition conditions. The H_2 permeation behaviors of the transition metal coated V membranes were examined in order to replace the Pd-based H_2 separation membrane.

It has been revealed that the H_2 dissociation/ recombination properties of the Ni catalytic layer are much better than that of the Co. Moreover, The H_2 permeability of the Ni coated V membrane largely depended on the electrodeposition time. The coverage of the Ni catalyst particles on the V substrate is increased with an increase in the electrodeposition time, resulting in an increase in the H_2 permeability gradually. However, after the V surface is fully covered with the Ni particles, the H_2 permeability is decreased abruptly because the diffusion through the Ni lattice of the dissociated H atoms becomes a rate-determining step.

The effects of an amorphous Ni-P coating on the H_2 permeability and the durability of the V membrane will be further discussed to replace the Pd-based H_2 separation membrane.

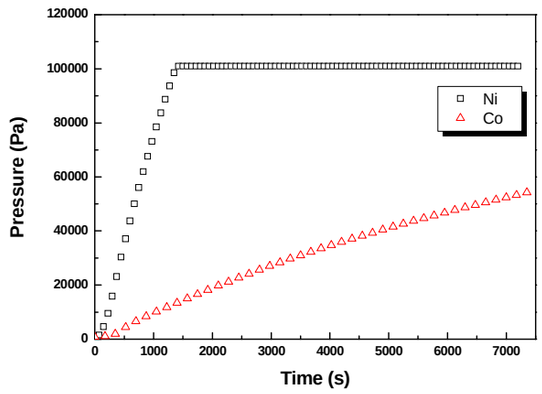

Fig. 1 H_2 permeation behaviors of the Ni and Co coated V membranes at 400 ^oC.

References

[1] S. Yun, S.T. Oyama, Correlations in palladium membranes for hydrogen separation: A review, J. Membr. Sci. 375 (2011) 28-45.

[2] M.D. Dolan, Non-Pd BCC alloy membranes for industrial hydrogen separation, J. Membr. Sci. 362 (2010) 12-28.