STUDY OF HYDROGEN PERMEATION THROUGH THE STAINLESS STEELS

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The exhaust gas after consumes the fossil fuel induce air pollution and the greenhouse effect. To protect the earth environment, we have to engage to decrease these pollutions. On the other hand, we are now facing a crisis of using up the fossil fuel in the earth. The new energy system is necessary to provide the enough and clean energy in the next generation.

The hydrogen energy system is one of the solutions to solve these problems. The hydrogen energy system fundamentally has no disease gas exhaust into the environment. The system would be constructed by many materials; the stainless steels must be one of the major structural one. In this study, we estimated a hysteretic relationship between the hydrogen permeation in a metal.

The samples were pipe of SUS-304 and SUS-306. Deuterium gas was used as the permeation gas for the purpose to decrease the effect of background hydrogen from the environment. The first, pipe was filled by deuterium gas up to several atmospheric pressures, and the outside was evacuated to give a driving forth to the deuterium gas. Then the specimen was heated up to 623 K and cooled down again to the room temperature. Then the rate of deuterium gas permeation through the stainless steel was continuously measured by the quadruple mass spectrometer (QMS) system. After the permeation treatment, the specimen surface was observed by a scanning electron microscope (SEM).

Figure 1 shows the relationship between the rate of deuterium permeation in a non-charged SUS-304 of the 1-mm thickness and time. No deuterium gas can permeate through the non-hydrogen charged specimen under 373 K. If the temperature was increased up to 423 K, the deuterium gas rapidly permeates the SS: at the higher temperature the more the deuterium gas permeates.

Figure 2 shows the relationship between the permeation rate of deuterium through the SUS-304 and the temperature. No deuterium gas was permeated through the non-hydrogen charged SS under 400 K. A logarithmic relationship can be held between the permeation rate and the temperature over the range of 400 K. In this range, the permeation rate was increased with the temperature. After the permeation treatment, the rate does not change under 500 K. The reason can be considered to be the formation of irreversible lattice deformation induced by the deuterium permeation, it can be observed on the SEM photographs, Figure 3. The activation energy in 500~600 K was estimated as 42.36 kJ/mol. The value is approximately same as the value of hydrogen through SUS-304 (54.84 kJ/mol) reported by Grant et al.

Reference: D. M. Grant et al., Hydrogen in 304 steel, J. Nucl. Mater. 149, 180-191 (1987)

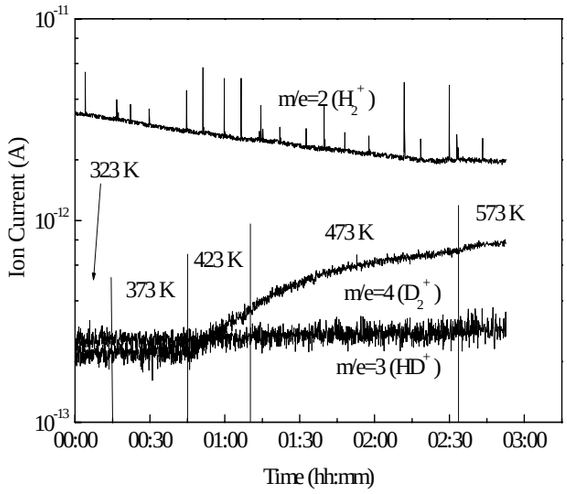

Figure 1: Ion current of m/e=2~4 measured by QMS

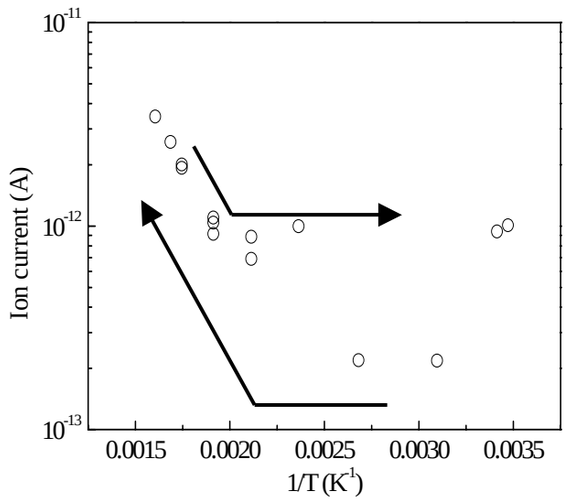

Figure 2: The permeation rate of deuterium through SUS-304 with temperature

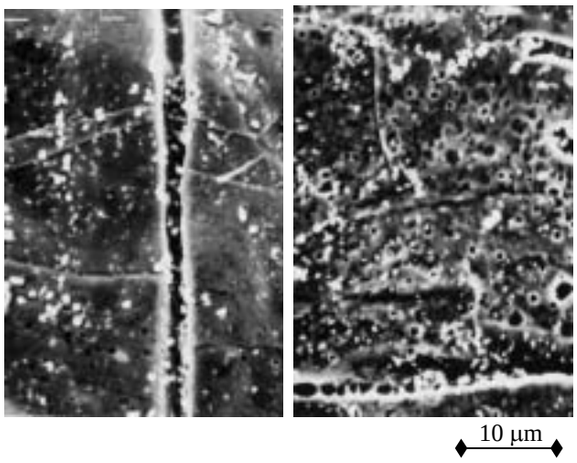

Figure 3: Surface photographs of SUS-304 observed by SEM; left is before deuterium permeation, right is after