§44. Design of Carbon Sheet Pump for LHD and Demonstration of Hydrogen Pumping

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Carbon Sheet Pump (CSP) proposed in the Large Helical Device (LHD) project to achieve high plasma performances with low overall recycling ratio is designed to be mounted on the vessel wall near the divertor plate. It is operated in the cycle of (1) pumping of charge-exchanged (CX) fast H neutrals by trapping them in the sub-surface layers of the carbon at temperatures below 200°C in the total duration time of about 100 s, (2) degassing of trapped hydrogen by direct Joule heating of the carbon sheet at a temperature above 800°C in a period between main discharges, and then (3) cooling down to the operation temperature below 200°C.

The first demonstration of CSP has been successfully carried out [1] by measuring the hydrogen pumping capacity and degassing efficiency using DC glow discharges in the plasma processing teststand (PPT)[2].

Discharges were initiated between a stainless steel anode rod and a coaxial cathode of 1.5 mm thick C/C sheets having the total surface area of 1,000 cm² in a constant gas flow of 50 % H₂ mixed in He. The system pumping speed was fixed to 1 l/s for He. All discharges were operated in the range of the sheet temperature below 150°C.

Figure (a) shows the H₂ partial pressure changes with starting DC glow discharge of ~ 550 V and ~ 0.6 A. About 0.6 to 0.8x10¹⁷ H atoms/cm² was gettered by the C/C sheet in 400 sec of discharge. The amount depended on regeneration temperatures at 450°C to 890°C for 80 sec. The impinging energy of hydrogen ions H₂⁺ or H⁺ on the CSP cathode in this DC glow experiments is lower than about 600eV, and results of saturation amounts are well explained by the energy dependence of hydrogen saturation reported in [3]. The total pumping speed of the 1,000 cm² carbon sheet is estimated to be

effectively less than 1 l/s as shown in Fig.(a). This apparently small value is explained by presuming the hydrogen ion fraction of only a few % in He ions and the electron density of about 10¹⁰ cm⁻³ with the temperature of a few eV.

In regeneration of the C/C sheet after gettering hydrogen, the thermal desorption of H₂ and CH₄ gases was observed as shown in Fig.(b), where the gas analyzer was calibrated with pure H₂ and CH₄ gases. The integrated amount of H atoms desorbed as H₂ and CH₄ was about 0.9x10²⁰ H atoms and this was almost comparable to the total amount of once gettered hydrogen.

Fig.(a)The H₂ partial pressure changes upon initiation of glow discharge on CSP sheets at room temperature after cooling down from regeneration temperatures indicated.
(b) Time evolutions of H₂ and CH₄ partial pressures and the CSP temperature under the direct Joule heating.

References

- 1) A.Sagara et al, 11th PSI Conference, 1994.
- 2) M.Natsir et al, 11th PSI Conference, 1994.
- 3) G.Staudenmaier et al, J. Nucl. Mater. 84 (1979) 149.