§39. Effect of Impurity Deposition on Membrane Pumping

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We develop a membrane pumping system in divertor region for LHD. The membrane pumping has been already demonstrated by using a large cylindrical Nb membrane and atomizers. The long-term operation with TPD plasmas has been carried out successfully. However, there are several R&D issues for application of the membrane pump to nuclear fusion devices. One of them is to investigate the effect of impurity deposition on membrane permeability for hydrogen particles.

A special Plasma Membrane Test Device (PMTD) as shown in Fig. 1 was fabricated to simulate the operational regimes of membrane pumping system in the divertor of fusion devices. A cylindrical Nb membrane (30 mm diameter, 150 mm length and 0.3 mm thickness) is placed along the axis of the main vacuum chamber and separates the upstream and downstream vacuum region of PMTD. The tubular membrane can be resistively heated by an electric current and the temperature of the membrane is controlled by the current. A cylindrical plasma is generated around the membrane by a hot-cathode duopigatrone and a Penning cell. Hydrogen atoms produced by the plasma permeate through the membrane. A stainless steel water-cooled target surrounds the plasma column. The target material is sputtered by energetic plasma ions, which are produced by applying a potential between the anode and the target, and serves as the source of impurities deposited onto membrane.

We have investigated the plasma driven permeation by measuring the outlet pressure and a specific sign of superpermeability is confirmed that the permeation probability does not depend on the membrane temperature. When a negative bias voltage was applied to the target, we observed the decreasing of plasma driven permeation flux due to the deposition of metal impurity as shown in Fig. 2. In this case the deposition rate is about 2 x 10^{14} cm^{-2} s^{-1} and much larger than that in the divertor region of the present plasma devices. This effect may be caused by decreasing the inlet surface potential barrier, that is, increasing the recombination coefficients of hydrogen. We confirmed the change of the membrane potential asymmetry in the course of deposition experiments. This deterioration of membrane pumping can be recovered by heating of membrane up to high temperature (~ 800 °C) because of the dissolution of metal impurities in the bulk of membrane and we can operate the membrane pumping system without the influence of impurity deposition in high temperature operational regime.

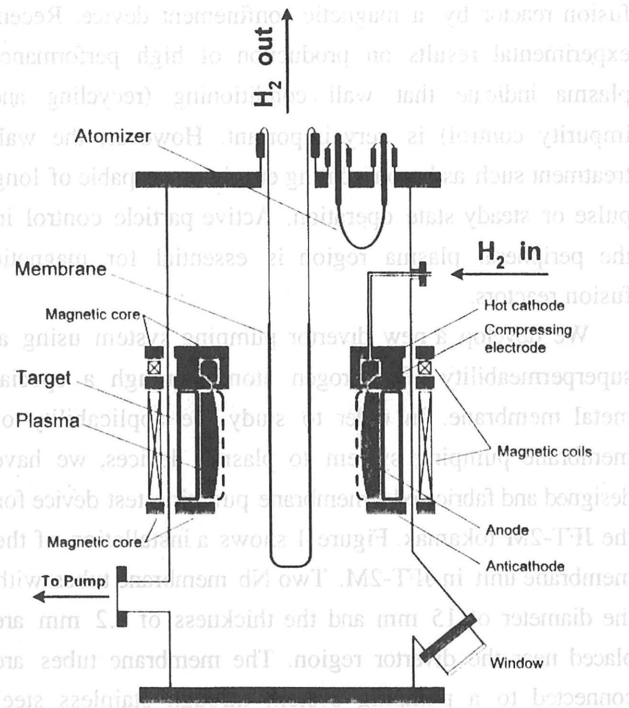

Fig. 1 Schematic view of Plasma Membrane Test Device

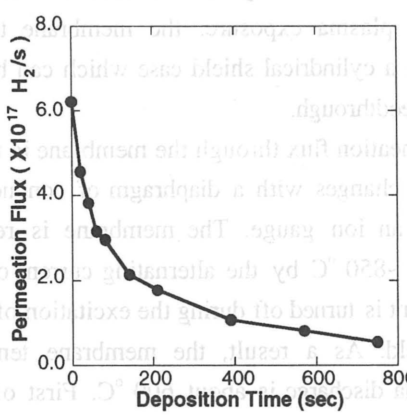

Fig. 2 Dependence of plasma driven permeation flux on stainless steel deposition time