§11. Development of Membrane Pumping Test Device

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Metal membranes made of Va group metals (V, Nb, Ta) can absorb a large amount of hydrogen. Moreover, such membranes can be permeated through by hydrogen atoms and ions with a high probability.

It has been proposed that the membranes apply to hydrogen pumping in nuclear fusion devices, which is called a membrane pumping system. The pumping system is expected to be a more powerful active pumping method than existing ones. Up to the present, the following have demonstrated;

(1) deuterium evacuation by a Nb membrane pumping system in fusion device (tokamak).[1)]

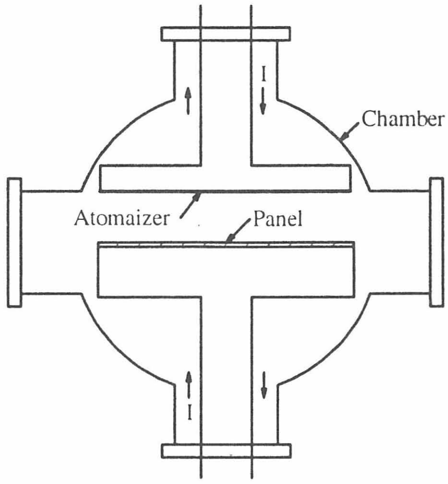
(2) effect of impurity deposition (stainless steel components and carbon) onto Nb membrane surface for permeation probability.[2)]

It was found from these results that the membrane pumping system seems to be promising.

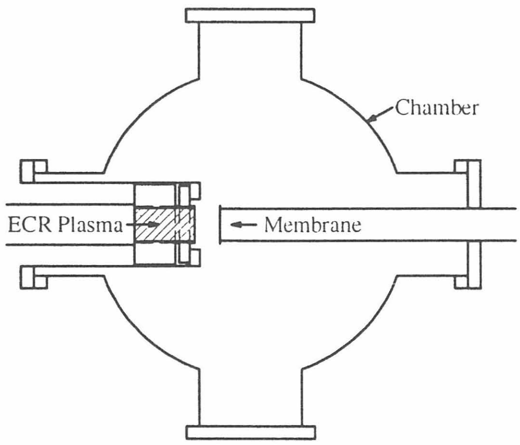
We have constructed a new experimental device in order to investigate the characteristics of the membrane pumping system in detail. The vacuum chamber is cylindrical, 60 cm in diameter and 100 cm in length. The vessel is evacuated by a turbo molecular pump with the pumping speed of 1000 l/s for H_2. The chamber can be baked out at 200 °C and the base pressure is < 10^{-6} Pa.

By using the device, we are going to simulate the absorption of hydrogen atoms by a membrane panel in the LHD. The schematic view is shown in Fig. 1 (a). The panel is made of Nb, 1 mm in thickness and 50 cm×50 cm in length and width. Hydrogen atoms are generated by the atomizer which is composed of Ta wires and resistively heated up to 2000 K by an ohmic current. The absorbed hydrogen particles are released by heating the panel up to ~500 °C. The total amount of absorbed hydrogen is measured by integrating the gas flow through a fixed conductance. The panel is being installed in the LHD in the next experimental campaign.

In order to employ the membrane pumping system in the divertor region, it would be favorable to operate the membrane at low temperature (room temperature) from the viewpoint of the reduction of energy consumption and Lorentz force due to the membrane heating current. Therefore, we are investigating to find the membranes capable of operation in lower temperature range. To clarify the characteristics, experiments with the chamber and an ECR plasma source is also planned. The membrane faces the plasma as shown in Fig. 1 (b). The plasma is produced by a magnetron (2.45 GHz) and magnets (resonance field: 875 G). A hydrogen atom flux of ~10^{15} $cm^{-2}s^{-1}$ is created at 21 cm in front of the plasma source. The permeation probability of the membrane made of various metal will be investigated over the temperature range from room temperature to ~500 °C.



(a) Setup with a membrane panel.



(b) Setup with an ECR plasma source.

Fig. 1. The schematic view of experimental setups.

Reference

1) Nakamura, Y. et al.: J. Nucl. Mater. **278** (2000) 312.

2) Nakahara, Y et al.: *to be published in* Fusion Eng. Des.