§43. Development of Membrane Pump for Plasma Devices

Suzuki, H, Ohyabu, N., Sagara, A.
Livshits, A., Notkin, M.(Bonch Univ.)
Komatsu, K (Nagoya Univ.)

Introduction

To evacuate hydrogen particles is a key for enhancing a plasma performance in fusion devices. Superpermeable membrane pump is a candidate for hydrogen pump of the LHD. The advantages of the membrane pump are 1)high efficient hydrogen pumping, 2) no saturation of the pumping, 3) no mechanical part (it is operational even under high magnetic field.), 4) no cold part. Such advantages are especially important for fusion devices.

Some kinds of metals exhibit a special phenomena, called "superpermeation"[1]. Hydrogen atoms, not hydrogen molecules, can pass through the Superpermeable membrane with the permeation probability of one, if the hydrogen atoms have energies of more than 1eV, a typical surface potential energy. If the probability of desorption at the outlet surface is larger than that of inlet surface (e.g. the barrier of outlet surface is lower than the inlet surface) the hydrogen particles will be mostly released at the outlet surface as molecules. Consequently hydrogen particles which pass through the Superpermeable membrane are automatically compressed at the outlet side of the membrane. The key point of the superpermeation is a potential barrier on the surfaces of the metal which produced by non metallic impurities. Hence surface conditions is very important for the superpermeation. However, experimental studies has been carried out mostly in ultra high vacuum chamber using atomizer, which is usually incandescent metal wire. In this study, we used plasma as atomizer and studied pumping effect

Experiment

Superpermeable Membrane Pump System(MPS) was fabricated to investigate its pumping properties under the conditions similar to those of the divertor. This MPS including a cylindrical superpermeable niobium membrane with thickness of 0.1mm , diameter of 12cm. The MPS is installed in TPD, which is a linear plasma device at NIFS, The TPD produces a plasma with an electron temperature of < 10eV At this region, hydrogen atoms are produced mainly by dissociation process of

$$H_2 + e^- = H + H + e^- \quad (1).$$

The production rate of the hydrogen atoms by plasma can be estimated as follows.

$$Q = F(T_e) n_e n_{H_2} \quad (2)$$

where F is a function of the electron temperature[2]. Two regions are separated by the membrane. If there is no permeation, the pressures of inlet side and outlet side are independent. However, when permeation begins, the pressure of the outlet side start to increase. Thus, using pressure gauges, we can estimate the permeation flux.

Fig.1 shows the relationship between the estimated hydrogen production rate and the permeation rate. The permeation rate is proportional to the production rate of the hydrogen atoms, showing that the permeation probability is constant. Thus, this result can be understood that the hydrogen atoms which are produced by dissociation process in the plasma passed through the superpermeable membrane, and the permeation probability is constant. Somewhat low permeation probability is also understood by considering of a shadowing effect of support structure of the MPS.

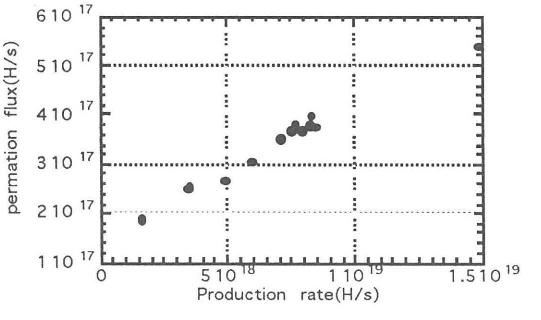

Fig.1 the relationship between the estimated hydrogen production rate and the observed permeation rate

Summary

The Superpermeable membrane pump in a plasma device successfully pump out hydrogen atoms which produced by plasma continuously. No technical difficulty in operating the superpermeable membrane pump was found. From this study, we believe that Superpermeable membrane pump is an effective hydrogen pumping system for fusion devices.

References

[1] A.Livshits, et.al.,J.Nucl.Mater.178(1991)1
[2] M.F.A.Harrison "Physics of Plasma-Wall Interactions in Controlled Fusion" p.281 (1986)