§46. Plasma Stainless Wall Interaction in the LHD

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Stainless steel is often used for ultra high vacuum vessels. However, it is known that steel contains hydrogen particles in the bulk. Thus, if a stainless steel vacuum vessel would be used for a plasma vacuum vessel, characteristics of hydrogen stainless steel interaction must be studied. There have been several studies on hydrogen in steel. However, the hydrogen particles of the studies are naturally-exist hydrogen in the steel or introduced by chemical method, electric method and abrasion method. It must be studied whether hydrogen particles in steel, which is implanted by plasma, have same feature or not.

The plasma vacuum vessel of the LHD is made of stainless steel SUS316L, with a thickness of 15mm. During the second campaign, NBI armor tiles with a total area of 3m^2 were installed. They were only carbon plasma facing compornents in the LHD, and they are negligible compared with stainless steel area with a total area of 730m^2. A neutral gas pressure has been measured by a fast ionization gauge (FIG) which is operational in a high magnetic field. Using FIG data, gas puff information, and pumping speed, the particle balance in the LHD can be analyzed.

The plasma experiments have been carried out by using hydrogen and helium gas. In the case of helium gas, no or very small missing particle exist. However, in the case of hydrogen, almost half of the input hydrogen particles have disappeared. This is due to wall pumping effect. The wall pumping effects have been observed only during plasma shots. This shows that the wall pumping has been caused by implantation, not surface absorption. In the case of hydrogen, outgassing from the wall has also observed. However the particles which have released from the wall were small. Most of the implanted hydrogen particles have stayed in the steel for a long time. Fig 1 shows typical pressure curves of the hydrogen and helium gas with line density curves.

According to R.Calder, desorption rate of hydrogen gas from a stainless steel could be explained by diffusion[1]. Fig.2 shows the desorption rate of hydrogen gas from the wall of the LHD. It looks as if two kinds of constant exist, i.e. there are two kinds of trapped states of hydrogen in stainless steel. R.C.Frank have reported two different diffusion constants of hydrogen in steel[2]. Y.Ishikawa reported double peak structure of a thermal desorption spectroscopy (TDS) analysis of hydrogen in SUS316L[3]. In general, measured diffusion constants and solution ratios of hydrogen in steel below 500K is vary[4]. These varieties and two kinds of trapped state are explained by several kinds of trapping sites. The tight trapping site with high activation energy is consider to be from lattice defects[4]. At first, implanted hydrogen particles are trapped at loose trapping sites, then diffuse with low activation energy. Some part of the hydrogen particles reach the surface and are released. The other parts of the hydrogen particles reach tight trapping sites and stay there. This is a scenario of hydrogen desorption from the stainless steel wall of the LHD.

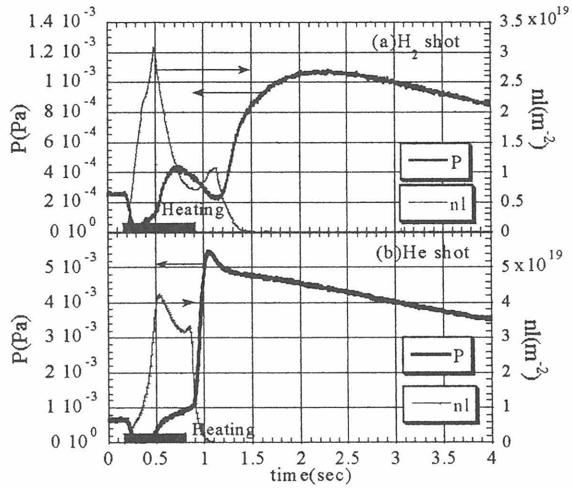

Fig.1 Typical pressure curves of hydrogen shot(a) and helium shot(b) with line density curves

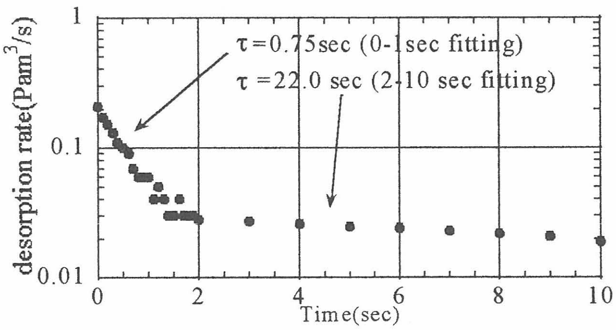

Fig.2 Desorption rate if hydrogen gas from the wall of the LHD

References
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