§1. Deuterium Retention in Low-Activation Ferritic Steel under Deuterium-Plasma Exposure

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Deuterium density retained in low-activation ferritic steel such as JLF1 [1], a candidate for structure materials in nuclear fusion devices, is important for designing the devices. We have measured deuterium (D)-density in JLF1

Mechanically polished JLF1 is exposed to D-plasma generated by AC glow discharge of 1.5 KV in 67 Pa D_2 at room temperature, using the method in [2]. D-density was evaluated using nuclear reaction, $D(^3He,\alpha)P$. For analysis of D-density, JLF1 is treated as Fe, as in the case of stainless steel (SUS).

D-density is obtained to be ~0.1 % for D-plasma exposure time of 30 min (D fluence of ~9x10^{17} cm^{-2}), using 1.0 (□) and 0.7 (△) MeV $^3He^+$ beams with the detection geometry N: normal incidence and nuclear reaction angle of 160 º (Fig. 1). As already reported, the energy of α-particles is not single-value function of depth in this detection geometry. Thus, region of depth where D-density can be analyzed is 0.6–1 μm and 0.2-0.6 μm for 1 and 0.7 MeV $^3He^+$. D-density integrated over 0-0.2 μm is obtained to be 14x10^{15} cm^{-2}, using 0.7 MeV $^3He^+$. If these D's are assumed to be uniformly distributed within 0.2 μm from the surface, N_D/N_{Fe} yields to 0.8 %. Here N_D and N_{Fe} are D-density and Fe density (N_{Fe}=8.48x10^{22} cm^{-3}). Also shown in Fig. 1 is the depth profile (○,●) obtained using the detection geometry B (incidence of 20 º and detection angle of 70 º measured from the surface normal, nuclear reaction angle of 90 º) and 1 MeV $^3He^+$. In this case, the energy of α-particles is single-value function of depth and the depth resolution near the surface is estimated to be 30 nm, considering the energy resolution of solid state detector of 32 keV. The maximum D-density is obtained to be 2.6 % and is larger by a factor of 3 than the average D-density mentioned above, indicating that considerable amount of D's is trapped very near surface. For depth larger than 0.2 μm, D-density obtained with the detection geometry B is approximately half of that obtained with the detection geometry N. D-density vs D-plasma exposure time is shown in the inset of Fig. 1, indicating that D-density saturates at 10 min. Fig. 2 shows escape or release of D's from the JLF1 as a function of days after D-plasma exposure. Measurements of D-density in SUS, dynamic retention of D in JLF1 and SUS, and thermal desorption of D are under way.

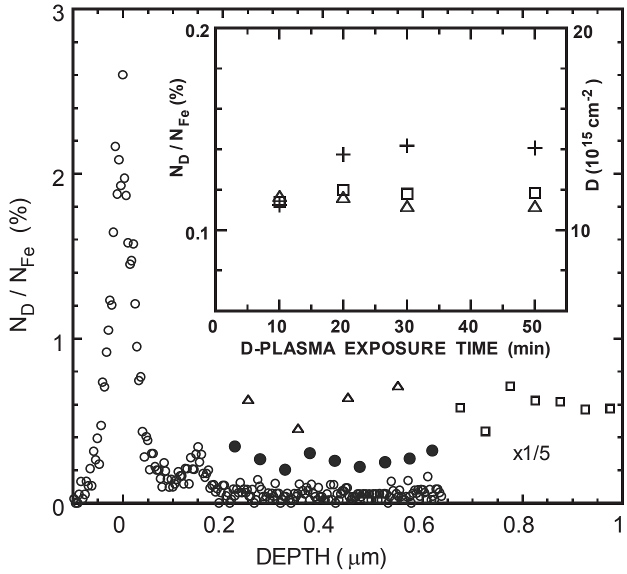

Fig. 1 Deuterium density vs depth in JLF1 obtained using 1 MeV ^3He(○,●,□) and 0.7 MeV ^3He(△). D-exposure time is 30 min. D-density (●, △, □) is to be multiplied by 1/5. Inset illustrates D-density vs D-plasma exposure time. D-density integrated over 0-0.2 μm is indicated by +.

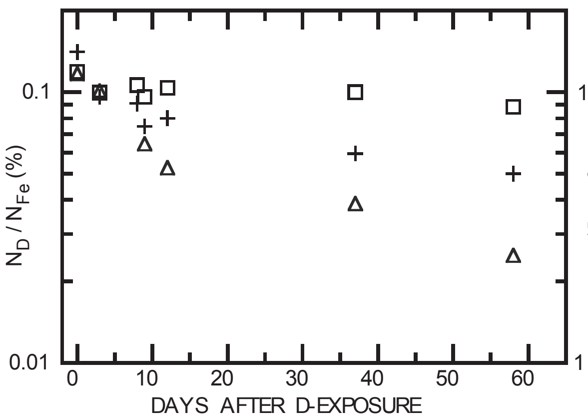

Fig. 2 D-density averaged over 0.2-0.6 μm (△), 0.6 -1μm (□) vs days after D-plasma exposure. D-density integrated over 0-0.2 μm is also shown (+).

1. T. Nagasaka, Y. Hishinuma, T. Muroga, Y. Li, H. Watanabe, H. Tanigawa, H. Sakasegawa, M. Ando, Fusion, Eng. Design, 86(2011)2581.
2. N. Matsunami, T. Sogawa, Y. Sakuma, N. Ohno, M. Tokitani, S. Masuzaki, Phys. Scr. T415(2011) 014042.