§2. Deuterium Density Retained in Low-Activation Ferritic Steel under Low-Energy Deuterium-plasma Exposure

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Low-activation ferritic steel, e.g., JLF1 [1] is a candidate for structure material in nuclear fusion devices. Hence, deuterium (D)-density retained in the steel is important for designing the devices. We have measured D-density in JLF1 under low-energy D-plasma exposure.

Mechanically polished JLF1 is exposed to deuterium-plasma generated by AC glow discharge of 1.5 KV in 53 Pa D_2 at room temperature, using the same method in [2]. D-plasma consists of 60 % D_3^+ and 40 % D_2^+ (D^+ can be negligible) [3]. D-density was evaluated employing nuclear reaction, $D(^3He,\alpha)P$, analysis (NRA) with normal incidence and NRA angle of 160^o measured from the incident beam direction. For analysis of D-density, JLF1 is treated as Fe, as in the case of stainless steel (SUS).

Figure 1 shows NRA spectra for D-plasma exposure time of 50 min (D fluence of ~$2x10^{18}$ cm^{-2}), obtained using 1.0 and 0.7 MeV $^3He^+$ beams. Peaks around 1.6 and 1.9 MeV are α-particles from D located near the surface of JLF1. It appears that for 0.7 MeV $^3He^+$, majority of D's ($1.4x10^{16}$ cm^{-2}) are retained within the depth of 0.2 μm (comparable with the depth resolution of 0.21 μm corresponding to the solid-state-detector resolution of 25 keV). If these D's are assumed to be uniformly distributed in the depth of 0.2 μm, 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}). D-density was obtained with the calculated relation between the energy of α-particle and depth, as shown in Fig. 2 and it is noticed that the relation is not single-value function for 1.0 MeV $^3He^+$. D-density is shown in the Fig. 1 inset and one sees that D-density is ~0.1 % for the depth of 0.2-0.6 μm and ~0.2 % in the deeper region. The results imply that D's migrate from the deeper region towards surface and a certain amount of D's is trapped very near surface, and it is more likely that some D's escape from the surface, because the total amount of D's and D-density near surface region decrease after D-plasma exposure. It also appears that D-density in unpolished JLF1 is larger by a factor of 1.5 than that in polished JLF1. Measurements of D-distribution in SUS, dynamic retention of D in JLF1 and SUS, and thermal desorption of D are under way.

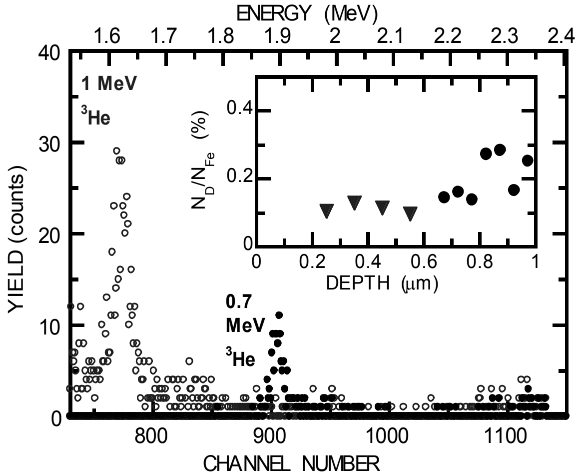

Fig. 1 NRA spectra of α-particles for JLF1. D-density vs depth (inset) obtained by 0.7 MeV ^3He (▲) and 1 MeV ^3He(●).

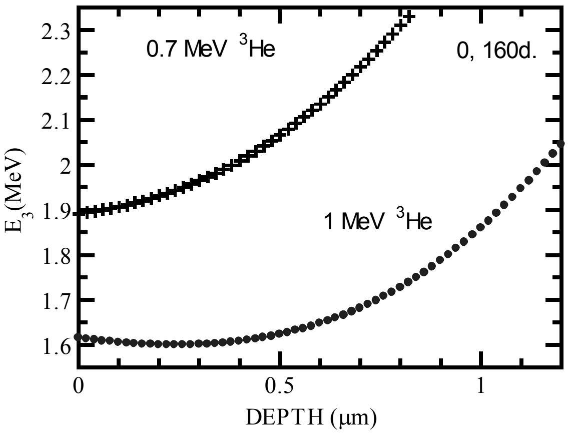

Fig. 2 Calculate energy of α-particle vs depth for 0.7 MeV ^3He (▲) and 1 MeV ^3He(●) in Fe.

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