§23. Retention Dynamics in Damaged Tungsten

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Recent studies show neutron damaged sites in tungsten can trap significant tritium in the bulk. Detailed studies of damage characteristics, local concentration, dependence of dpa, and difference between ion damage and neutron damage are under progress. Since neutron damaged sites are created in the bulk of tungsten, their tritium uptake could reach unacceptable amounts even in DEMO reactors with relatively high wall temperatures. Recent studies show that radiation damage could be related to multiple trapping of single defects[1] (vacancies and so on). It is important to understand detailed mechanisms for prediction of tritium behavior in tungsten.

For detailed studies on nature of trapping sites, it is necessary to inject hydrogen isotope ions or atoms into tungsten without making significant additional damage. In this study, we changed injection conditions of D ions to investigate how to reduce ion induced trapping site production and to find best way to evaluate characteristics of ion damaged trapping sites. For this purpose we compare two ion energy cases, 1 keV and 0.15 keV.

In this study, Ion damage was made by 6.4 MeV Fe ions at 573 K. Then D ions with the energy of 1 keV and 0.15 keV were injected up to the fluence of 1.5 x 10^{24} m^{-2}. Residual D in tungsten was measured by TDS with the temperature ramping rate of 0.1 K/s.

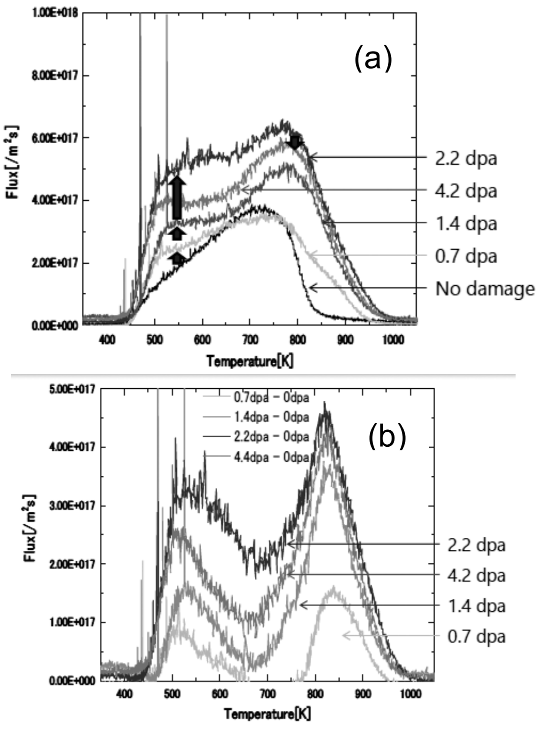

Fig. 1 TDS data for different damaged W. (a) Raw data. (b) Difference between damaged and undamaged W data.

Figure 1 shows TDS data for several damaged tungsten from 0 dpa to 4.2 dpa irradiated with 1 keV D at 473 K. Tungsten samples were heat-treated at 2000 C, under which recrystallization and grain growth were clearly found. Under this condition, still significant release of D was observed for undamaged W, see Fig. 1 (a). D release was seen up to about 800 K. Total retention is similar to that of 0.7 dpa case. As ion damage was raised, two distinct release peak was observed around 500 K and 800 K, which could be related to ion damaged sites.

For reducing ion beam driven trapping sites, the ion energy was reduced to 150 eV, which is lower than displacement threshold. The result is shown in Fig. 2 at 423 K with a fluence as a parameter. For damaged W, there were two release peaks, one from 500 K to 700 K and the other

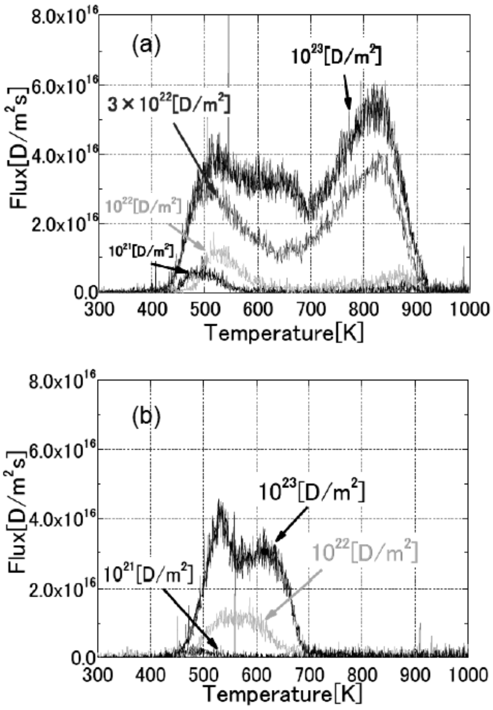

Fig. 2 TDS data for damaged (a) and undamaged (b) . Ion energy is 0.15 keV at 423 K.

around 800 K. For irradiation to undamaged W, D release from 500 K to 700 K was only observed. Therefore, it is clear that the release peak around 800 K closely relates to high energy ion damage sites. There seems the other release peak around 500 K, which could relate to low trapping energy sites (this could be mono-vacancy). But to obtain detailed information on this site better method to reduce ion-driven trap site production. If occupation ratio of these sites are trap-number dependent, the peak could shift to low temperatures or could broaden. But from the results, no such peak modification was not seen for the high temperature peak around 800 K, which could suggest that the D trapping sites corresponding to the high temperature peak does not have occupation dependent trapping energy.

[1] K. Ohsawa et al., PHYSICAL REVIEW B **82**, 184117 (2010).