# §67. Effects of Surface Mixing Layers of Tungsten on Hydrogen Isotope Behavior

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It is well known that surface mixing (modified) layers of tungsten formed by mixed ion irradiation (D/He, D/C, and et al.) strongly affect hydrogen isotope behavior such as T retention, recycling, and permeation. For example, mixed ion irradiation of D and C enhances blister formation on tungsten [1]. D/He mixed ion irradiation greatly reduces D retention in tungsten[2]. In order to clarify the mechanism of these and to make appropriate models, it is important to know quantitative results and systematic database. However, there have been very few studies on quantitative D atom behavior under controlled mixed ion irradiation. In this study, tungsten samples irradiated with D/C and D/He mixed ion beam or plasmas were exposed to tritium gas and amount of trapped T in the surface modified layers was measured by IP (Imaging Plate) to know the trap site density in these modified layers.

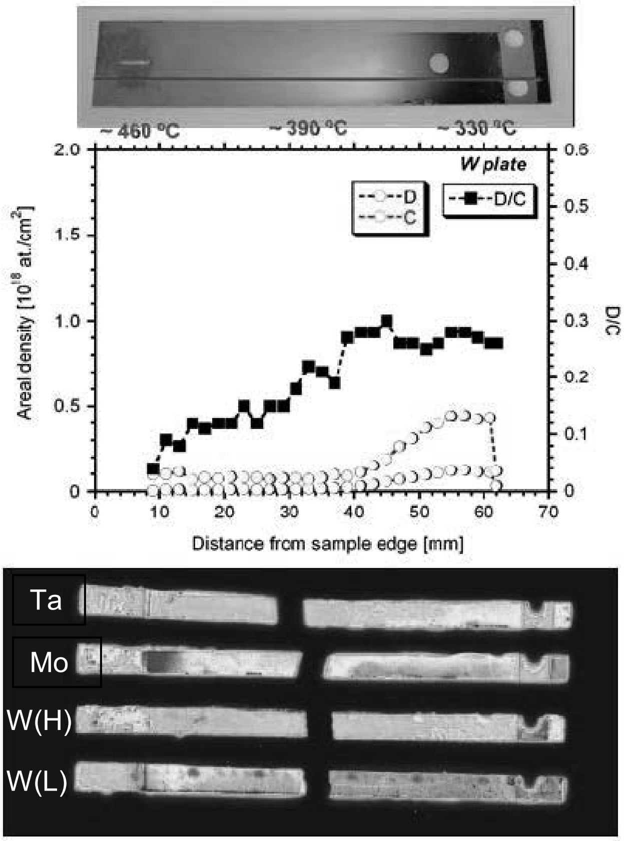


Fig. 1 From upper to bottom, photo of a tungsten sample with partial carbon deposition , C and D surface density profiles measured by NRA, and IP images for Ta, Mo W (high temp.) and W (low temp.)

Figure 1 shows an example of a measured sample and results. In this case, a tungsten plate with temperature gradient was irradiated with D/C mixed ion beam. Since chemical sputtering yield is dependent on surface temperature, carbon deposition was observed only near the low temperature side (~330 ˚C). From a carbon deposition profile shown in the middle of Fig. 1, a C surface density profile measured by NRA clearly correlated with dark color area on the upper photo, indicating carbon deposition. D surface density is also high in this C deposition area. IP images are shown in the bottom of Fig. 1, indicating tritium surface density is clearly correlated with amount of carbon deposition.

Intensity of IP signal (PSL, Photo stimulated luminescence) as a function of surface C density was shown in Fig. 2. It was found that T concentration (PSL values) is a simple function of C surface density regardless of substrate materials (Ta, W, Mo). In addition, T concentration is continuous around C deposition threshold suggesting T/C ratio did not vary much between the W/C mixed layer and the C deposition layer. As the exposure temperature increased to 300 ˚C, some of T diffused into the bulk.

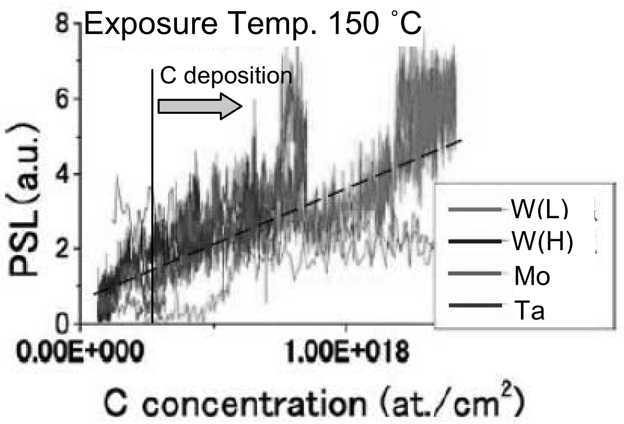


Fig. 2 Carbon concentration dependence of PSL value.

Surface damage induced by mirror polishing and its annealing behavior was investigated by exposing tritium gas to recrystallized tungsten. It was found that 900 C annealing for 1 h greatly reduced trapped T in damage site by a factor of about 5, indicating 900 C annealing is very effective to reduce surface trap sites. But as annealing temperature was raised to 1300 C, surface-trapped T was increased by double. At this temperature, recrystallization proceeds, which could affect surface modification and new trap site creation.

Finally, surface T trapping by W samples exposed to different plasmas (He, Ne, Ar, N2) was investigated. It was found that only He plasma exposed samples showed high T trapping compared with a non-exposed sample (900 C annealing) by about an order. The other samples showed only twice increment of surface T trapping. We confirmed that He induced trap sites are most significant and it is important to study this He effects on T behavior.

[1] Y. Ueda et al., *Nucl. Fusion* **44** (2004) 62.
[2] M. Miyamoto et al., *Nucl. Fusion* **49** 065035.