Recent findings on blistering and deuterium retention in tungsten exposed to high-fluence deuterium plasma

W. Shu\textsuperscript{a}, A. Kawasuso\textsuperscript{b} and T. Yamanishi\textsuperscript{a}

\textsuperscript{a}Tritium Process Laboratory, Japan Atomic Energy Research Institute, Tokai-mura, 319-1195 Ibaraki-ken, Japan
\textsuperscript{b}Positron Beam Laboratory, Japan Atomic Energy Agency, Takasaki, 370-1292 Gunma, Japan

wataru.shu@iter.org

Blistering occurs at tungsten exposed to high-fluence deuterium plasma, even if the ion energy is too low to create displacement damage [1, 2]. In this study, blistering and deuterium retention in various tungsten exposed to high-fluence (up to $10^{27} \text{D/m}^2$) of high-flux (10\textsuperscript{22} D\textsuperscript{+}/m\textsuperscript{2}/s) and low-energy (38 eV) deuterium plasma were examined in the temperature range of 315 K to 1000 K with scanning electron microscopy (SEM), focused ion beam (FIB), thermal desorption spectroscopy (TDS) and positron annihilation (PA).

At the exposure temperature of 315 K, only low-dome blisters with sizes of less than a few microns appeared even if the fluence reached $10^{27} \text{D/m}^2$. At around 400 K, the blisters became much denser and the dome of blisters became a little higher. Peculiar change occurred around 500 K, where two kinds of blisters appeared. One is the large blisters with sizes of a few tens of microns and varying ratios of height against chord (up to 0.6), and the other is the high-dome small blisters with chords of less than a few microns and large ratio of height against chord (about 0.7). Blisters became much sparser as the temperature increased to above 600 K and disappeared at 1000 K. In addition, the phenomenon of blister bursting with a tail, or partially-opened or fully-opened lid was found after plasma exposure or TDS experiments. During TDS experiments, bursting release with numerous sudden peaks was newly observed by setting the time resolution of quadrupole mass spectrometer to about 0.3 s. Deuterium retention showed the maximum around 500 K, corresponding to the appearance of two kinds of high-dome blisters. Furthermore, the amount of deuterium retained in tungsten increased with the increasing fluence, roughly following the proportional relationship with the root of the exposure time.

Besides the strong dependence upon the exposure temperature, blistering and deuterium retention also showed significant dependence upon the features of microstructure. For plasma exposure at 315 K, blistering occurred more significantly on the un-recrystallized and single crystal W samples than the partially and fully recrystallized W samples. The unrecrystallized W sample showed the largest retention ratio at the same fluence. Preliminary PA measurements suggested the possibility of vacancy generation in the near-surface region of tungsten due to the deuterium plasma exposure.

References:

Number of words in abstract: 393
Keywords:
Technical area: 23. Radiation effects He and H effects
Special session: Not specified
Presentation: No preference
Special equipement: No special equipment