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Deuterium retention in tungsten under fluences up to 10^29 m-2

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Hydrogen retention in tungsten is an important topic for fusion energy, which involves both tritium safety and the lifetime of wall components (therefore plasma operation). The topic is also of scientific interest considering the uncertainty in hydrogen behaviors in metals such as trapping and diffusion, and the impact on material's properties. So far, the study of hydrogen retention in tungsten is limited by plasma parameters such as plasma fluence and exposure time. The highest accumulated plasma fluence in ITER and CFETR divertor is predicted to reach 10^30-10^31 m-2, which is far beyond the accessible fluence (~10^28 m-2) in laboratory by linear plasma devices.
To provide as much data as possible in terms of ITER- and CFETR- relevant fluences, the main objective of this research is to study deuterium retention in tungsten under fluence up to 10^29 m-2 using the linear plasma device STEP at Beihang University, China and Magnum-PSI at DIFFER, the Netherlands. The relationship between deuterium retention and plasma fluence will be measured in different conditions, such as tungsten microstructure (rolled, recrystallized tungsten and so on), sample temperature (500 K~1200 K), pre-damage conditions (up to 2 dpa by ion beam) and special surface modifications (blister).
At present, preliminary experiments have been done using STEP and Magnum-PSI. A fluence of 1×10^28 m-2 after a single continuous exposure at a sample temperature of ~500 K has been achieved in both devices. Surface morphology changes and thermal desorption spectroscopy were measured. In the STEP experiment using recrystallized tungsten samples, a saturation of deuterium retention is not achieved at fluence up to 1×10^28 m-2, and the analysis of thermal desorption spectrum indicates a possible relationship between deuterium trapping and blister-induced defects. While in the Magnum-PSI experiment, it is quite interesting to find that blisters were rarely observed though the exposure fluence and temperature were quite similar to those in STEP. The difference in the sample biasing voltage is proposed to explain the difference.
The following experiments are on-going. And the project is expected to establish a database of hydrogen retention in tungsten under ITER- and CFETR- relevant plasma fluences and reveal the mechanism of trapping and diffusion in tungsten. These activities will contribute to the evaluation of tritium safety and the lifetime of wall components.

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