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Effect of defect concentration and distribution on hydrogen isotope retention and diffusion in damaged W for fusion first wall

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Elucidation of tritium dynamics is one of the key issues for sustainable D-T fusion. Tungsten will be exposed to high fluxes of tritium (T) accompanied with various energetic particles. Therefore, T retention and its trapping states will be dramatically changed by the accumulation of ion and neutron-induced damage and recovery by heating. These facts motivate us to perform extensive hydrogen isotope retention experiments in damaged W under the framework of Japan/US joint project, PHENIX. This paper presents recent results, including an analysis of D retention by various methods over a range of defect concentrations.
Disks of stress-relieved W were irradiated using 6 MeV Fe2+ at room temperature in TIARA, JAEA or 6.4 MeV Fe3+ at higher temperature in DuET, Kyoto University up to 1.0 dpa. These samples were then compared with neutron-damaged W (10-6 dpa for 14 MeV or 10-4 dpa for thermal neutrons). All the samples were exposed to 1 keV D2+ up to a fluence of 1.0 × 1022 D m-2 at room temperature. Thereafter, thermal desorption spectroscopy (TDS) was applied with the heating rate of 0.5 K s-1 up to 1173 K.
The D2 TDS spectra from Fe2+ damaged W showed that accumulation of damage shifted to higher desorption temperature, consistent with the formation of large voids. For W specimens damaged by 14 MeV fusion neutrons to 10-6 dpa, the D2 desorption at 700 K was found even at low defect concentrations, suggesting that the collision cascades result in the formation of vacancies. The simulations showed that D accumulated within 0.5 μm of the exposed surface for W damaged by Fe2+ ions.
The results of D permeation experiment showed that D permeability for damaged W was reduced by damage introduction. Furthermore, by heating above 1100 K, D permeability were completely consistent with that for undamaged W. The nature of the defects is critical, and their stability will strongly influence D permeability.
In summary, the accumulation of defects resulted in the formation of stable trapping sites. The D trapping by defects reduces the number of available D diffusion pathways through the lattice, a mechanism that could lead to a reduction of D permeability. Finally, we note that dynamic recovery of damages is enhanced by high temperature irradiation.

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