# SIMULATION OF HYDROGEN ISOTOPE RETENTION IN TUNGSTEN UNDER FUSION-RELEVANT CONDITIONS

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As a primary candidate for Plasma-Facing Materials (PFMs), Tungsten (W) in magnetic confinement fusion devices will be exposed to high-flux neutron and plasma irradiation at elevated temperatures. Under these extreme conditions, Deuterium (D) and Tritium (T) from the plasma diffuse into W and become trapped at defects, leading to D/T retention. This retention is a major concern, as it not only affects plasma stability and fuel recycling but also poses safety risks due to long-term T accumulation. Additionally, neutron irradiation increases defect density in W, which may further enhance D/T trapping and complicate fuel management [1-3]. Despite extensive experimental studies on hydrogen isotope retention in W, the combined effects of neutron irradiation-induced defects and steady-state plasma exposure remain insufficiently understood, particularly under reactor-relevant conditions. A modeling approach can enhance this understanding, quantify retention mechanisms, and provide valuable insights for guiding material design in future fusion reactors.

In this work, we present a computational framework that integrates a neutron irradiation defect and microstructure evolution model [4] with the Migration of Hydrogen Isotopes in Materials (MHIMS) model [5] based on rate equation modeling. This framework simulates the steady-state conditions of the W blanket armor and the W divertor monoblock in the EU-DEMO reactor. The maximum surface temperatures of the W armor and monoblock are 900 K and 1500 K, respectively, with thermal gradients of 300 K and 900 K toward the heat sink [6,7]. Both components experience a peak neutron irradiation dose of 1 dpa under a fusion-relevant neutron energy spectrum. In this model, the D and T concentrations at the plasma-facing surface are fixed and assumed to have reached saturation, establishing a constant concentration gradient across the W component and ensuring a steady-state diffusion profile. The simulation captures the evolution of neutron irradiation-induced defects, such as dislocation loops and voids, at different locations of the W components (as shown in Fig. 1) and evaluates D/T retention within these defects. Finally, this work provides insight into hydrogen isotope retention in tungsten components under fusion-relevant neutron irradiation conditions.

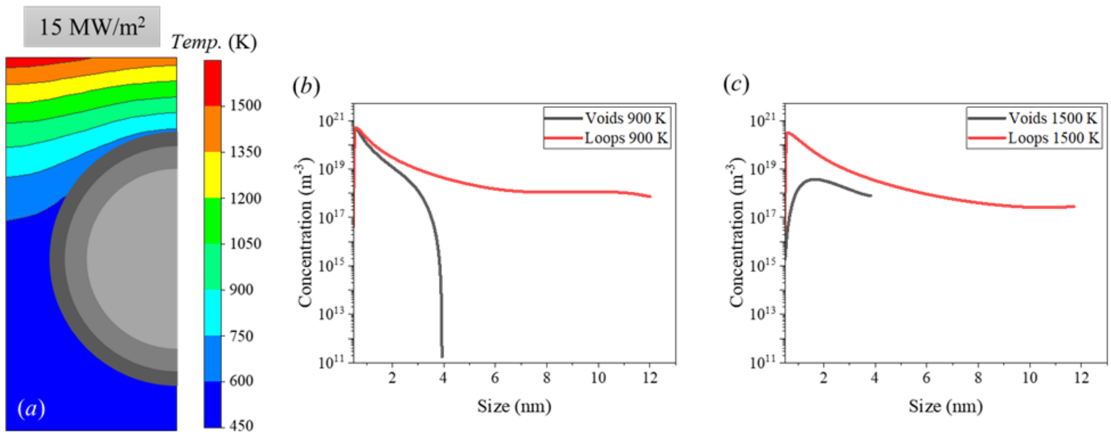


*Figure 1 (a) Temperature profile of divertor monoblock [7]; voids and loops size and concentration at (b) 900 K and (c) 1500 K with a neutron dose of 1 dpa.*

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