Contribution ID: **87** Type: **not specified**

Synergistic effects in annealed W simultaneously exposed to D plasma

Monday, 4 October 2021 14:10 (30 minutes)

Damaging or annealing of tungsten (W) samples while simultaneously exposing them to hydrogen isotope plasma has been shown to strongly affect the creation/recovery of displacement damage in the material compared to sequential damaging/annealing and subsequent plasma exposure. Such synergistic effects have a strong effect on hydrogen isotope retention and permeation in plasma-facing components. Since both neutron damaging and plasma exposure will happen at the same time during the operation of a fusion device, conducting simultaneous experiments and studying phenomena that arise due to the synergistic effects is of great importance for understanding and predicting fuel retention and material evolution.

In this experiment, W samples have been self-damaged and annealed either with or without deuterium (D) plasma exposure. Samples annealed in vacuum were only exposed to D plasma at lower temperature after annealing in order to populate the remaining defects, whereas plasma-annealed samples were first exposed to D plasma to populate the defects and then annealed at elevated temperature with ongoing plasma exposure. After annealing, they too were exposed to D plasma at lower temperature to populate the remaining defects. Both annealing schemes were performed at the annealing temperature of 473 K, 573 K, 673 K, and 773 K for 1 h. The samples were analyzed by NRA and TDS techniques.

This experiment demonstrates that strong synergism occurs when annealing is accompanied by D plasma exposure. While defect concentration drops monotonically with annealing temperature in the case of vacuum annealing, which is in agreement with the literature data, the defect recovery in the plasma annealing case is much more complex, as trapped D probably stabilizes the defects and prevents their migration and recombination. Early modeling attempts of the experimental data will be presented.

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Session Classification: Plasma-driven Permeation