# Studies of plasma-driven hydrogen isotope permeation through wall materials for ITER and CFETR

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Understanding tritium (T) transport through wall materials is extremely important for future fusion devices such as ITER and CFETR to control their tritium cycle. Recent studies have highlighted the possibility that T may penetrate through the unshielded structure material into the coolant [1,2], an effect previously ignored in permeation analyses. Additionally, developing viable ways to reduce T permeation flux [3,4] is an urgent task for the design CFETR. Recently, plasma-driven hydrogen isotope permeation through candidate wall materials for future fusion devices has been extensively studied at the Institute of Plasma Physics, Chinese Academy of Sciences to address the above-mentioned problems.

ITER-relevant plasma-facing material, i.e. tungsten (W), was exposed to deuterium (D) plasmas in a linear plasma device. The permeation flux through W has been measured in-situ allowing the surface recombination coefficient to be experimentally evaluated. Systematic sample biasing effects experiment were performed to understand the dependence of the permeation flux on the incident particle energy. The results indicate that high energy (100-200 eV) implantation does not necessarily increase T permeation flux. 316LN stainless steel, oxygen-free copper and a copper alloy (CuCrZr) have been tested by D plasma and neutral atom exposures in the linear machine as well. It has been found that D permeation fluxes driven by neutral atoms through these materials can be one order of magnitude higher than those plasma exposure cases. XPS analysis indicates that those neutral-exposed samples have thicker surface contamination layer, which may result in weaker surface recombination (i.e. higher permeation).

The effect of surface barriers on the T permeation flux was studied in another set of experiments investigating two different situations: (1) the effect of a W coating on the plasma-exposed side of the structural material; and (2) the presence of a downstream barrier. When the original RAFM steel surface is covered by tens of nm thin W deposition, the permeation flux is enhanced by 2 to 5 times, which is in contradiction with intuitive consideration. On the other hand, a simple downstream surface oxidization can effectively reduce D permeation flux by a factor of 1000.

[1] H.-S. Zhou et al., J. Nucl. Mater. 493 (2017) 398.
[2] H.-S. Zhou et al., Nucl. Fusion 59 (2019) 014003.
[3] H.-S. Zhou et al., Nucl. Fusion 58 (2018) 056017.
[4] H.-D. Liu et al., J. Nucl. Mater. 514 (2019) 109.