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ABSTRACT:

Deuterium Retention In and Water Production From Tungsten Oxides Irradiated with Deuterium Ions

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Harnessing nuclear fusion's power is the goal of the ITER tokamak, an experimental project under construction in Cadarache (France) involving 35 nations. In a tokamak fusion reactor, a magnetically confined plasma of hydrogen isotopes (deuterium and tritium, the fuel mixture) is heated to millions of Kelvin and power exhaust is realized on the divertor tiles made of tungsten. A detailed understanding of the interaction of tungsten with fusion fuel is needed, especially because tritium is a scarce and radioactive element. Current fusion reactors show varying oxygen contamination on tungsten tiles, from sub-monolayer to micron-thick layers [1]. In this presentation, we will go through a series of studies probing the behavior of tungsten oxides upon deuterium fuel exposure. We will make a special focus on deuterium beam experiments aiming to disentangle the complexity of plasma-material interactions. Tungsten native oxide appears to resist deuterium ions sputtering and leads to significant trapping of deuterium in the bulk of tungsten. To better understand this behavior, the interaction of deuterium ions is compared for different surface states of tungsten. The clean surface of tungsten, tungsten covered with half-a-monolayer of oxygen atoms, tungsten covered with a few nm native oxide and tungsten covered with a 100 nm WO3 thin film were studied in depth. On the one hand, the retention of deuterium on the surface or in the bulk appears to depend strongly on the surface state [2]. On the other, the evolution of the oxygen coverage upon deuterium irradiation depends on the oxide thickness and water production is observed only for oxides with sufficient thickness [3].

[1] C. Martin et al., Phys. Scr. 96, 124035 (2021).
[2] A. Dunand et al., Nucl. Fusion 62, 054002 (2022).
[3] M. Ialovega et al., Nucl. Fusion 65, 076024 (2025).