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Parameter dependence of dynamic D retention in W

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Dynamic deuterium (D) retention properties of tungsten (W) have been investigated under steady-state D plasma exposure in the PISCES-A linear plasma device [D. Nishijima et al., Nuclear Fusion 61 (2021) 116028]. In contrast to static retention, dynamic retention is quickly released from the material after the termination of the incident plasma flux. Thus, an in-operando laser-induced breakdown spectroscopy (LIBS) system has been developed. A procedure was, first, established to extract the dynamic retention component from the in-operando LIBS D I 656.1 nm line intensity, which can contain multiple contributions from dynamic and static retention as well as background D/D_2 gas, excited by both steady-state and laser-induced plasmas. Then, based on a simple assumption, a conversion factor from the directly measured intensity ratio, D I 656.1 nm/W I 429.4 nm, with LIBS, to the D/W atomic fraction was roughly derived.

Using the developed in-operando LIBS system and procedure, the dynamic D retention in W was systematically examined while scanning the following plasma exposure parameters: incident ion energy, sample temperature, incident ion flux. Note that, in each parameter scan, the other parameters were kept as constant as possible. Our experiments revealed the following properties of dynamic D retention in W:
(1) No clear incident ion energy dependence is seen in the range of ˜45–175 eV.
(2) The dynamic retention monotonously decreases with increasing sample temperature from 348 to 573 K.
(3) The dynamic retention linearly increases with increasing ion flux, and then saturates above 0.75×10^{21} $\mathrm{m^{-2}s^{-1}}$.
In addition, sequential pure He, followed by pure D, plasma exposures showed that the dynamic D retention is not strongly affected by He bubbles in the near-surface region. Our observed trends on the incident ion energy and the sample temperature are qualitatively consistent with predictions from a global model [E.A. Hodille et al., Physical Review Materials 2 (2018) 093802], while there is a discrepancy in the ion flux dependence.

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