Technical Meeting on Plasma Physics and Technology Aspects of the Tritium Fuel Cycle for Fusion Energy

Contribution ID: **29** Type: **Invited Oral**

Tritium in chamber materials, trapping and release (plasma chamber in DEMO, irradiation damage and tritium trapping)

Thursday, 13 October 2022 11:15 (35 minutes)

Mechanisms underlying tritium retention in chamber materials can be roughly divided into two groups: trapping in deposition layers and that in bulk of materials. The contribution of trapping in the bulk to the total tritium retention could be larger in DEMO than that in existing fusion devices due to far longer discharge pulse that allows diffusion of tritium into deeper region of the materials.

Significant increase in fuel retention in W was observed after neutron irradiation to 0.01-1 dpa due to trapping effects by radiation-induced defects [1,2]. Nuclear reaction analyses of deuterium (D) profiles in neutron-irradiated D-plasma-exposed W showed that D concentration increased with decreasing temperature and reached ˜1 at.% at 200 ˚C after irradiation to 0.3 dpa, Penetration depth of D into neutron-irradiated W was proportional to the square root of plasma exposure time [3,4]. The rate of penetration depends on damage level (trap concentration), temperature and hydrogen isotope flux (H/trap ratio). Penetration depth was ˜50˜100 micrometers after plasma exposure for 3 h at temperature of 500 ˚C and flux of ˜10²¹ D m⁻²s⁻¹ [5]. The TDS measurements for neutron-irradiated W showed broad peaks extending from plasma exposure temperature to ˜1000 ˚C [2]. The apparent trapping energy was 1.4-2eV [2,5,6]. Because of the relatively large trapping energy, the fuel release at a moderately elevated temperature (˜300 ˚C) was very slow [7]; the tritium removal by bake out process should be very difficult. If W monoblocks with cooling channels are used in DEMO, tritium should penetrate to cold regions around the cooling channels and be accumulated there. Nevertheless, He seeding in D plasma resulted in drastic reduction in D retention in neutron-irradiated W [8], Alloying with Re and Cr (and probably accumulation of Re by transmutation) significantly enhance annihilation of vacancy-type defects and consequently reduce fuel retention after irradiation [9,10].

Tritium trapping in deposition layers were examined via post-mortem analysis of W and Be tiles used in JET ITER-like wall experiments under the Broader Approach Activities [11]. The summary of the analyses will be given in the presentation.

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Session Classification: Tritium Behaviors and DEMO Fuel Cycle

Track Classification: Interface btw First Wall & Fuel Cycle Technology