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Investigation of hydrogen recycling property and its control with hot wall in long duration discharges on QUEST

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Hydrogen (H) recycling and wall pumping properties on a dynamic retention dominant wall (metal wall) have been investigated in a medium size spherical tokamak QUEST. The plasma facing wall on QUEST originally made of stainless steel type 316L (SS316L) and partially coated by atmosphere plasma splay tungsten has been already covered with re-deposition layer of 5-100 nm in thickness due to plasma exposure. The re-deposition layer is composed of carbon, tungsten, ferrite, chromium and nickel according to X-ray photoelectron spectroscopy (XPS) measurement. Nuclear reaction analysis (NRA) is applied to specimens exposed QUEST H plasmas with exposing deuterium (D) plasma of approximately 1 eV, and presence of H-isotope barrier (HB) between the re-deposition layer and the substrate (SS316L) is confirmed due to little penetration to the substrate around 300-350K of the sample holder temperature. The HB must give a significant impact to H dynamic retention and a surface-recombination limiting model with HB is proposed. The model predicts a typical time constant representing wall saturation, which is relating to H flux to the wall, surface recombination coefficient, and thickness of re-deposition layer. In fact, the H storing capability on QUEST clearly depends on H flux and wall temperature experimentally. Especially time derivative wall stored H, that is wall pumping rate, has a clear relation to wall storing H and is well-fitted by the proposed model. Recently a hot wall is installed on QUEST to control H dynamic retention via modification of surface-recombination coefficient and its controllability of H dynamic retention in the range of 393K-473K is experimentally confirmed.

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