In situ Laser-Induced Breakdown Spectroscopy (LIBS) Study on Fuel Retention and Co-deposition in EAST Tokamak

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Plasma-wall interaction (PWI) research is an active field for long-pulse operation and steady-state nuclear fusion devices. To study the key PWI issues, such as the fuel retention, impurity distribution and co-deposition, laser-induced breakdown spectroscopy (LIBS) has been developed to diagnose the plasma facing components (PFCs) in Experimental Advanced Superconducting Tokamak (EAST) [1] and Wendelstein 7-X (W7-X) stellarator [2].

In this work, the PWI behaviors on the first wall from the high-field side of EAST have been investigated by an in situ LIBS system combined with optical emission spectroscopy (OES) and photomultiplier tubes (PMT). The D fuel retention on the first wall and the local edge D plasma condition have been simultaneously monitored during long-pulse operation scenarios by LIBS and OES, respectively. [3] Both LIBS and OES plasmas have been also measured by several PMTs with different narrow-band filters using multi-channel fibers. This method based on the PMT can significantly improve the system sensitivity for fuel and trace impurity elements. The results show that the thickness of the Li-D co-deposition layer was strongly related to the Li amount from wall conditioning and total discharge time. The fuel retention on the Mo first wall increased with the local D fluence from the region of edge plasma. The quantitative result by using the absolute calibration method shows that the edge D particle fluence of \( \sim 10^{24} \text{D/m}^2 \) and D retention amount of \( \sim 10^{20} \text{D/m}^2 \) on the first wall are achieved in long-pulse discharges with duration time of tens of seconds. An upgrade in situ LIBS with endoscope optical design to extend the detectable region to upper W divertor in EAST will be also presented in this work and will be used in the next experimental campaign. This work would further improve the understanding of fuel retention and co-deposition on the first wall in EAST and demonstrate the prospect of LIBS approach to in situ investigate PWI in the upcoming fusion device like ITER.

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