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Real-time wall conditioning through boron powder injection in fusion devices with carbon and tungsten wall.[1]

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Experiments carried out in DIII-D and ASDEX-Upgrade (AUG) injected boron (B) and B enriched powders during tokamak operation to obtain B coatings in real-time, i.e. during plasma discharges. Injection of isotopically enriched B into DIII-D H-mode plasmas (graphite plasma-facing components, PFCs) correlated with reduced wall fueling and impurity concentrations during the initial plasma current ramp. Surface analysis of substrates exposed only to plasma with B injection found B layers with the isotopic composition of the injected material, indicating active coating of PFCs. Improvement of wall conditions similar to boronization was also found in AUG (tungsten PFCs), where prior injection of B and boron nitride (BN) powder into H-mode plasmas resulted in reduced influx of O and W from the limiters. In both devices, the B injection appeared to be central for subsequent operation of low density scenarios. The results are interpreted through integrated modeling. First, the UEDGE code, including powder transport and ablation in the scrape-off layer (SOL) via the DUSTT code, is used to determine the flux of B ions to the PFC. Then, the growth of B layers is studied with the h-PIC and F-TRIDYN codes, which resolve the relevant processes of sheath acceleration, reflection, implantation, and sputtering. Results indicate that B powder injection at 10 mg/s can produce B ion fluxes ~10^{20} atoms/m^2 s to divertor PFCs. This appears to be sufficient to produce B-rich coatings of thickness comparable to glow discharge boronization (GDB). Achieving wall conditioning via injection of non-toxic B powder presents considerable advantages over GDB, which entails handling of hazardous gases, requires interruptions of experimental operation with possible evacuation of facilities and is inapplicable to long pulse devices, where coatings will significantly erode during a single plasma discharge.

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