6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Impact of Boron Powder Injection on Plasma-Wall Interactions and Core Confinement in WEST L-Mode Plasmas

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Glow discharge boronization (GDB) has been shown to significantly expand the WEST operating space by suppressing the sputtering of intrinsic impurities, namely oxygen which is responsible for significant tungsten surface sputtering [1]. The temporary lifetime of the deposited boron layers and the requirement to de-energize the superconducting magnetic field coils for GDB motivate a real-time wall conditioning alternative. To this end, an impurity powder dropper (IPD) provided by PPPL [2] was installed on WEST.

IPDs can drop a variety of low-Z powders at reproducible drop rates to provide real-time wall conditioning and/or to serve as an edge localized impurity source [3]. The installation of an IPD on WEST allows for the evaluation of the dropper as a real-time conditioning technique in a reactor-relevant environment on long-pulse time scales. In the WEST C5 campaign, 310 mg of B powder was dropped over 10 discharges using drop rates from 5 mg/s to 17 mg/s.

During the B drop, reductions of both deuterium and low-Z impurity particle fluxes were observed in the SOL. Following a discharge with powder injection, the subsequent discharge typically featured reduced radiated power (~10%) and reduced SOL low-Z impurity (~50%) and W (~10%) particle fluxes. In addition to the improvements in wall conditioning, discharges with B powder injection featured improved confinement (evidenced by an increase of 25% in W_{MHD} and a 200% increase in the neutron rate). These improvements in confinement were likely due to turbulence suppression from an increase in Z_{eff} and/or peaking of the electron density profile, possibly similar to observations on LHD [4]. Stability analysis of these discharges have been performed using a fast tokamak modelling code, METIS [5], and a quasilinear gyrokinetic code, QuaLiKiz [6]. IPD experiments in the C6 campaign will build upon the C5 results by dropping both B and BN powder into long pulse discharges (> 20 s) with higher drop rates (>17 mg/s). This will allow for an extensive characterization of the IPD as both a real-time wall conditioning method in a full-W environment and as a potential trigger for improved confinement scenarios.

References

[1] J. Bucalossi et al., 2021 Operation of a full tungsten actively cooled tokamak: overview of WEST first phase of operation *Nucl. Fusion* **62** 042007
[2] A. Nagy et al., 2018 A multi-species powder dropper for magnetic fusion applications *Rev. Sci. Instrum.* **89** 10K121
[3] R. Lunsford et al., 2019 Active conditioning of ASDEX Upgrade tungsten plasma-facing components and discharge enhancement through boron and boron nitride particulate injection *Nucl. Fusion* **59** 126034
[4] F. Nespoli *et al.* 2022 Observation of a reduced-turbulence regime with boron powder injection in a stellarator *Nat. Phys.*
[5] J.F. Artaud et al., "Metis: a fast integrated tokamak modelling tool for scenario design" 2018 *Nucl. Fusion* **58** 105001
[6] C. Bourdelle et al., "Core turbulent transport in tokamak plasmas: bridging theory and experiment with QuaLiKiz" 2015 *Plasma Phys. Control. Fusion* **58** 014036

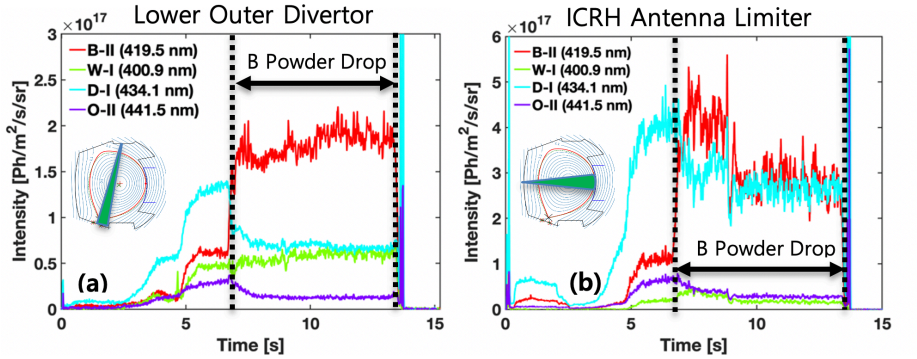

Figure 1. B-II (419.5 nm), W-I (400.9 nm), D_γ (434.1 nm), and O-II (434.1) line intensities at (a) the lower outer divertor and (b) the ICRH limiter.