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Effect of spatially non-uniform boronization on plasma restart in the full W environment of WEST

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The recent ITER re-baseline with the adoption of a full-W wall calls for mandatory boronization studies. Among existing W machines, the W Environment Steady-state Tokamak (WEST) offers a unique opportunity to study boronization effects on wall retention and plasma conditions thanks to its routine minute-long pulses and ITER grade, actively cooled divertor. In spring 2024, we carried out the first ever WEST experiment dedicated to boronization by repeating a sequence of identically programmed pulses before and after a boronization. In pulses after boronization, we initially observed a factor of 2 higher wall retention that vanishes after ˜100 s of plasma. On the other hand, throughout the whole post-boronization session (˜10 min of plasma), we measured a 20% lower radiated power, lower effective charge and lower UV line intensity for most impurities including oxygen, while keeping the same central electron density and temperature as well as same divertor regime as before boronization. In fall 2024, for the first time in five years, we attempted to restart plasma operations without boronization after a vent and after reinstalling W limiter tiles (replaced by BN tiles from 2020 to mid-2024). In 2 days of operation corresponding to ˜60 limiter pulses, we reached a maximum pulse length of 1.5 s and a maximum current of 600 kA. Plasmas were cold and dense, mostly detached from the inboard limiter and dominated by light impurities with radiated fractions close to unity and no particular sign of runaway electrons. We then carried out the first WEST boronization utilizing only 3 out of 6 diborane injection points, to study the effect of non-uniform B layers expected in ITER due to its toroidally asymmetric boronization system. Repeatable ohmic limiter pulses of 10 s were immediately achieved with a factor of 4 reduction of the oxygen signal from UV spectroscopy and radiated fractions between 50% and 70%. In the remainder of the campaign, we achieved 422 pulses corresponding to about 2 hours of cumulated plasma time and 12.5 GJ of cumulated injected/extracted energy over 5 weeks of operation without any further glow discharge boronization. These efforts culminated in a new record long pulse for WEST, which lasted for 824 s with 1.93 GJ of injected/extracted energy. Despite these successes, towards the end of the campaign, wall conditions started to show signs of degradation that would have made a new boronization desirable, should the experiments have continued further.