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Effect of boron coating on long pulse high confinement plasma in EAST with full metal wall

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Boron, as a low-Z material, is widely employed for wall conditioning to enhance plasma performance in fusion devices. Boron coatings including pre-discharge coating by using carborane (C2B10H12) as the working material assisted by ion cyclotron wall conditioning (ICWC) and real time coating have been successfully performed in EAST machine with full metal first wall [1].
After pre-discharge boronization, it was found the thickness of B film was about tens to one hundred nm and the surface of the sample was granular. The main composition of B film was about 50% B, 30% C and other elements including O, N, and W analyzed by XPS. The impurity radiation including oxygen and heavy impurities such as W, Fe, Cu and Zeff decreased significantly, which results in the slightly increased plasma stored energy. The lifetime of boronization was about 1700s in EAST. However, the H release was very serious during the initial plasma discharges after boronization due to H co-deposition during boronizaiton. To avoid introducing H isotopes, pure B powder with an average size of 70 μm was injected into plasma for real time boron coating. The reduction of the low-Z and high-Z impurities were observed[2], and the W impurity content could be decreased to 10-5 as the boron powder continuously injecting. Furthermore, it was found that the fuel particle recycling decreased with an increase in the amount of B powder injected. The fuel recycling decreased by up to 80%, and each B atom exhibited a trapping capacity of 0.3 D particles during B powder injection at a typical flow rate of 20 mg/s by particle balance analysis. The possible mechanism for D retention is the formation of B-C-O-D compounds and co-deposition between B and D particles during discharges [3] .
By performing these boron coatings, a high confinement mode plasma of >100s pulse duration with a controlled plasma density of 3.8×1019 m-3, the low H/(H+D) ratio to <10%, goal recycling coefficient <1 and core tungsten impurity concentration˜10-5 was successfully achieved in EAST. These advances provide a very valuable reference for evaluating boron application in ITER and future fusion reactor devices.

[1] G.Z. Zuo. Boron coating on full metal wall in EAST for supporting ITER new baseline, 26th PSI invited talk.
[2] W. Xu, et al. Active wall conditioning through boron powder injection compatible ELM control in EAST. Nuclear Materials and Energy, 2023, 34: 101359.
[3] G. Z. Zuo, et al. Deuterium recycling and wall retention characteristics during boron powder injection in EAST. Materials Research Express. 2023;10(12):126402.

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