8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Development of boron coating technologies for high performance plasma on EAST with full metal wall

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Boron coatings including pre-discharge coating by using carborane ($C_2B_{10}H_{12}$) as the working material assisted by ion cyclotron wall conditioning (ICWC) and real time coating have been successfully performed in EAST machine with the graphite and full metal first walls [1-3]. 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 Z_{eff} 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 [4], 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 an 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 [5].By performing these boron coatings, a high confinement mode plasma of >100s pulse duration with a controlled plasma density of 3.8×10^{19} m^{-3}, the low the amount of B powder injected. The fuel recycling

trapping capacity of 0.3 D particles during B powder 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.

References

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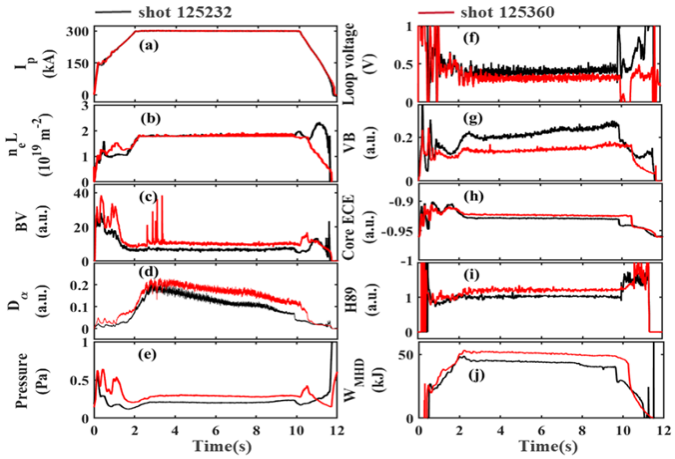

Figure 1. Time evolution of (a) Plasma current Ip, (b) Line-averaged electron density Ne, (c) Bv emission, (d) Dα light emission from the upper divertor zone, (e) Neutral pressure from the upper divertor, (f) Loop voltage plasma confinement factor, (g) the visible bremsstrahlung radiation VB, (h) Core ECE, (i) H_{89}, (j) Plasma stored energy W_{MHD}.