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The construction and experiment results of high-field-side divertor target biasing system (HDTB) on J-TEXT

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Recently, a toroidally quasi-symmetric distributed high-field-side divertor target biasing (HDTB) system has been newly installed on the J-TEXT tokamak. It aims to modulate the $\mathbf{E}\times\mathbf{B}$ drift in the scrape-off layer (SOL) under the high-field-side mid-single null (HFS-MSN) divertor configuration[1] by applying bias to the divertor targets. The $\mathbf{E}\times\mathbf{B}$ flows are believed to be able to modulate the asymmetric distribution of divertor parameters and increase the particle and heat flux characteristic lengths. The HDTB system consists of the upper biased target (UBT) array and the down biased target (DBT) array, which are misaligned in the magnetic flux surface coordinates[2], as shown in Figure 1(a). The UBT is entirely located within the SOL, and the DBT covers the down strike point and extends partially into the private flux region (PFR). Unlike the traditional hybrid biasing mode[3], the above scheme directly connects UBT and DBT to both ends of the power supply without grounding, which we refer to as the floating hybrid biasing (FHB) mode.

When the HDTB system operated in the positive FHB mode, i.e., a $+100V$ bias was applied between the UBT and DBT, the poloidal and radial electric fields ($\mathbf{E_\theta}$ and $\mathbf{E_r}$) were simultaneously driven due to the misalignment of the two target arrays in magnetic surface coordinates. They resulted in an outward radial $\mathbf{E_\theta}\times\mathbf{B}$ flow and a poloidal $\mathbf{E_r}\times\mathbf{B}$ flow directed toward the down divertor as illustrated in Figure 1(d). Consequently, these flows broadened the particle flux distributions in the SOL while modulating the asymmetric distribution in the divertor. Applying a -100V bias voltage instead reduced the decay length of the particle flux in the SOL, as shown in Figure 1(b-c) and (e-f). Furthermore, the impact of target biasing on impurity transport, detachment, turbulence, etc., is under ongoing analysis.

The experimental results preliminarily verify the HDTB system efficiency for mitigating extreme particle and heat flux as well as asymmetric distribution issues on the divertor target, which provides a possible solution for the future fusion reactors operating at high power and long pulses. More experimental data are being accumulated to support further development on J-TEXT.

References

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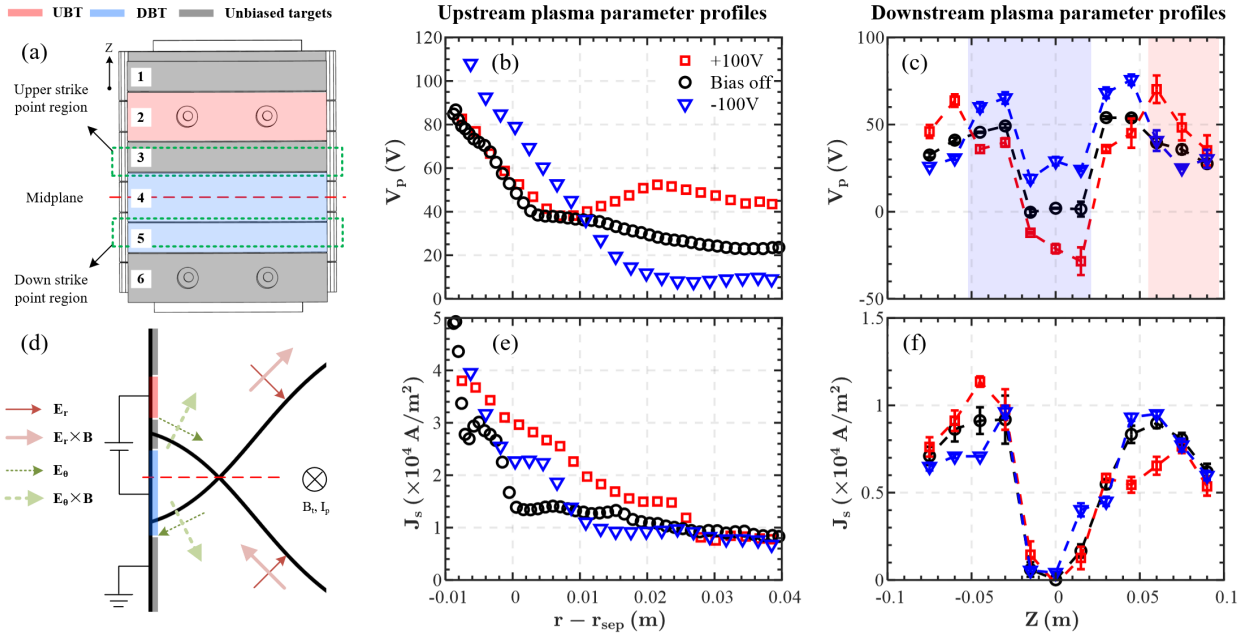

Figure 1. (a) Schematic diagram of the target biasing positions; (b) the schematic illustrates the directions of the $\mathbf{E_r}$ and $\mathbf{E_\theta}$, along with the corresponding $\mathbf{E_r}\times\mathbf{B}$ poloidal and $\mathbf{E_\theta}\times\mathbf{B}$ radial flow in SOL under positive FHB mode. Upstream and downstream plasma potential profiles (b) and (e), ion saturation current density profiles (e) and (f) are measured by the reciprocating probe and the HFS divertor target probes.