Physical design of EAST lower tungsten divertor upgrade by considering target erosion and W impurity transport

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The divertor target serves as the most intense plasma-surface interaction area in tokamaks, and the control of power load on the target becomes a critical issue for high performance long-pulse discharges. EAST has achieved H-mode operation over 100 s, however, its lower graphite divertor prevents its achievement of further high-power long-pulse discharges [1]. Tungsten (W) has been chosen as the divertor plasma-facing materials (PFMs) for ITER [2] and the main candidate for DEMO. To demonstrate the performance of W as the divertor target material for ITER and solve the power exhaust problem, EAST will upgrade its lower divertor into W material. In this work, the physical design of the new EAST lower W divertor is presented. By using the 2D edge plasma code SOLPS modeling [3,4], the new optimized divertor shape for the EAST discharge configuration is proposed after systematic examination of different target shapes, target angles and the pump locations.

To study the effect of external impurity seeding and the control of W impurity in the newly designed divertor, the performance of argon (Ar) and neon (Ne) seeding into the plasma, and the resulting W target erosion and its impurity transport were simulated by the SOLPS coupled DIVIMP modeling [4-5]. The simulation results indicate that seeding at scrape-off layer (SOL) side is better than seeding at private-flux region (PFR) by considering the divertor power dissipation and impurity screening. By comparing the Ne and Ar seeding, it is found that to achieve the similar divertor plasma condition, Ar seeding is better for divertor impurity screening. However, Ar may cause more serious W erosion, resulting in severe core contamination by W impurity. Our study indicates the erosion of W is still a critical problem during the Ar seeding, even with Te at the target below 10 eV. To reduce the target erosion and enrichment of W impurity in the core region, the deuterium gas puffing at upstream SOL region combined with external impurity seeding at divertor region is proposed. In addition, the effects of the electric drifts on the Ar impurity transport and W target erosion were studied. These studies will improve the understanding of W target sputtering and W impurity transport control during the radiative divertor discharges for CFETR/DEMO.