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Recent advances in EAST flowing liquid Li limiter experiments in support of divertor design for DEMO device

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The investigation on effect of the flowing liquid Li limiter (FLiLi) on fuel and impurity, and heat fluxe during high confinement mode (H-mode) plasma was recently performed in EAST, aiming to provide an alternative resolution for the divertor design of a future DEMO device. Four generations of liquid Li limiters have been have successively designed and tested including a thin flowing film concept augmented by a thermoelectric magnetohydrodynamic (TEMHD) effect in generation 4[1-3]. The FLiLi was inserted into the edge in EAST plasmas with a limiter temperature of 300–400℃ and an auxiliary heating power of max. 8.3 MW. Analysis has shown that by using FLiLi, fuel particle recycling continuously decreased, and ≥80% of retained D particles were captured by the continual renewal of the Li redeposition film during FLiLi operation[4]. Thermal desorption performance of D2 in Li have been conducted to investigate possible Tritium removal in future device[5]. Impurity particle radiation, including high-Z and low-Z impurities, decreased significantly during the sequence of FLiLi operation. The decreased impurity radiation and recycling led to a modest increase (˜10 kJ, 5%) in the plasma stored energy[6, 7]. Furthermore, H-mode could be easily access in an upper single-null configuration with ion grad-B drift away from the active divertor, reduce the L-H transition threshold power and gradually increase H mode duration (PRF˜ 3.4 MW) while using the liquid Li limiter. Additionally, ELM mitigation was observed, accompanied by enhanced edge coherent MHD mode (ECM) and an edge harmonic mode, which was similar to that observed during boron powder and impurity gas injection in EAST [7]. With low magnetic field (Bt˜1.9 T) and q95 ˜ 4.2, by using liquid Li, large ELMs were effectively mitigated, i.e. increased ELM frequency and a decreased ELM size. Furthermore, vapor shielding effect due to an inserted FLiLi was investigated in the EAST device. The obvious decreased temperature and surface temperature oscillations of the liquid Li were observed with the presence of a Li vapor cloud during H mode discharges. A sudden Li burst probably due to Li droplet ejection from limiter surface produces a strong Li radiative band and decreases liquid Li surface temperature directly monitored by IR camera. Thermal analysis of the Li vapor indicated that the neutral Li vapor shielded >42% of the parallel heat flux, at the areas with relatively weak interaction. These results will provide a reference to design divertor with high heat flux in future reactors by allowing for a self-healing, self-replenishing surface with no susceptibility to neutron damage to partly ameliorate lifetime and power-exhaust issues of PFCs.

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